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REPORTS AND NEW RECORDS

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DROSOPHILA CAUVERII – A NEW SPECIES OF *DROSOPHILA* FROM COORG DISTRICT WESTERN GHATS, SOUTH INDIA

N. MUNIYAPPA, G. SREERAMA REDDY & H. S. PRAKASH

Department of Post-graduate studies and Research in Zoology,
University of Mysore, Manasa Gangothri, Mysore, India - 570 006

(Received 5 October 1980)

A new species *Drosophila cauverii.* a member of the *montium* sub-group of the *melanogaster* species group, collected from the banks of river Cauvery in Coorg destrict is described. The taxonomic status and relationships are discussed.

(Key words: Drosophila cauverii, new species, *montium* sub group)

Coorg district is a part of Western Ghats situated on the South-Western part of Karnataka state between north latitude 11° 56′ and 12° 50′ and east longitude 75° 22′ and 76° 11′. It is a picturesque highland occupying the eastern and western slopes of the Western Ghats, clothed with primeval forests and grassy lands, broken by a few cultivated valleys with heavy rain fall for nearly half of the year providing congenial environment for colonization by the members of genus *Drosophila*. The *Drosophila* survey made at the banks of river Cauvery near Kudige about 30km to the north-east of Madikeri has yielded a new species, *Drosophila cauverii*, which is herein described.

Drosophila cauverii. sp. nov.

Body length: Male 2.3 mm; Female 2.5 mm.

Head: ♂ and ♀: Arista with 8 branches (5/3) including the terminal fork. Front pale brown. Antenna dark brown. Basal segment of the antenna orange yellow. Greatest width of cheek 0.1 greatest diameter of eye. Carina narrow. Palpi yellow and slender. Ocellar triangle small and orange. Ocellar bristles long, proclinate. Inner verticals longer, outer verticals slightly shorter than inner ones. Orbital bristles in the ratio of 3:1:3. Eyes red.

Thorax: ♂ and ♀: Brown. Acrostichal hairs in 8 rows, regularly placed. Ratio anterior: posterior dorsocentrals 0.6. Mesonotum light yellow. Scutellum light brown. Anterior scutellars convergent; posterior scutellars crossing each other. Sterno-index 0.6. Prescutellars absent. Halteres yellow.

Legs: Preapical bristles on all tibiae. Apicals on first and second tibiae. Male fore legs (Fig. 1) with longitudinal sex-combs along entire length of metatarsal and second tarsal segments. Metatarsal comb consisting of 15—18 teeth, smaller basally, longer distally, the distal 2 displaced from axis of remaining teeth. Comb on second tarsal segment with 11—13 uniform teeth.

Wings: ♂ and ♀: Transparent. *C*-index, 2.00; *4V*-index, 2.6; *5X*-index, 1. 6: *M*-index, 0.9 (Wing indices calculated after Bock, 1976). Third costal section with heavy setation on basal 0.5. Wing lengths: 1.8mm (male); 2.1mm (female).

Drosophila (sophophora) cauverii sp. nov.
Fig. 1. Fore leg of male showing sex-combs.

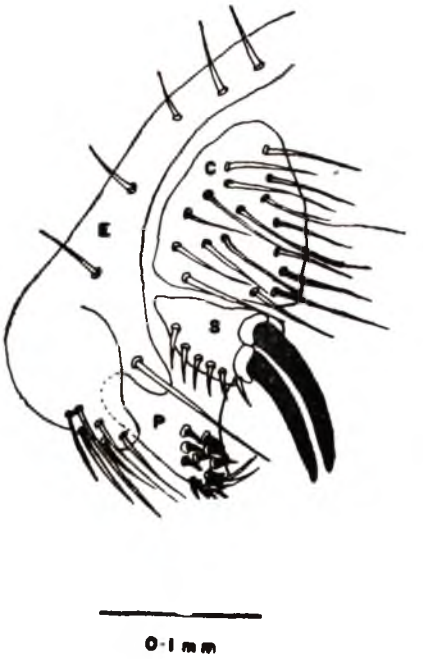

Fig. 2. Periphallic organs. C — Cerci; E — Epandrium; P — Primary surstylus, S — Secondary surstylus.

Abdomen: ♂ and ♀: Tergites of both sexes yellowish. First five targites of female and first four tergites of male with dark apical bands, remaining tergites of both sexes unbanded.

Periphallic organs: (Fig. 2): Epandrium (Genital arch) yellow, broad dorsally and laterally. Toe small and rounded with about 6 bristles. Primary and secondary surstyli (claspers) present. Primary surstylus yellow, broad with 6—7 randomly distributed lateral teeth and a ventro medial cluster of 8—9 bristles, two of which are long and curved. Secondary surstylus dark yellow separated from cerci (anal plates), with 2 large curved black medial teeth and a row of 5—6 small bristles along the ventral border. Cerci light black, triangular with 16—18 bristles.

Phallic organs: (Fig. 3): Aedeagus yellow, slender, bare, tapered and curved dorsally. Anterior gonopophyses (anterior parameres) short, broad, tip rounded with 4—5 minute sensilla. Posterior gonopophyses (posterior parameres) long slender, reaching the tip of aedeagus. Caudal margin of novasternum with elongate median truncate process, apically with a pair of short sub-median spines. Basal apodeme projecting the anterior border of ventral fragma.

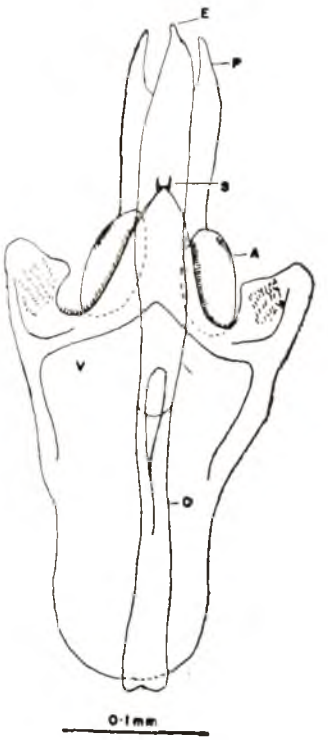

Fig. 3. Phallic organs. A — Anterior gonopophyses; E — Aedeagus; O — Basal apodeme of Aedeagus; P — Posterior ganopophyses; S — Submedian spine of novasternum; V — Ventral fragma.

Egg guide: (Fig. 4): Lobe brown, with 15 marginal teeth and a sub-terminal hair inserted between 3rd and 4th marginal teeth.

Internal structures: Testes (Fig. 5) yellowish with three and half coils. Accessory glands large and transparent. Spermathecae (Fig. 6) vestigial, par ovaria small, ventral receptacle long, tightly coiled. Malpighian tubules two pairs, free.

Egg filaments: (Fig. 7): 2. long slender, not flattened apically.

Pupae: Anterior spiracle with 10 black branches.

Distribution: Coorg district (Western Ghats), Karnataka, India.

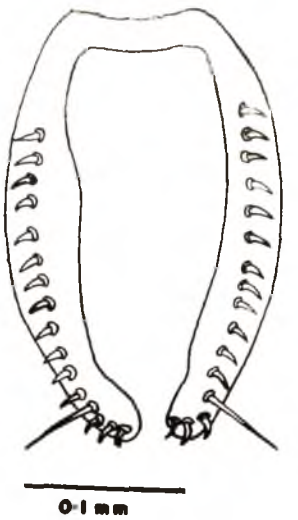

Fig. 4. Egg guide.

Holotype ♂, INDIA, KARNATAKA, Coorg district (Western Ghats), banks of river Cauvery near Kudige, 12.1.1980. Coll. N. Muniyappa, G. Sreerama Reddy, H. S. Prakash and D. Theertha Prasad. **Paratypes** 10 ♂♂ and 10 ♀♀: same data as

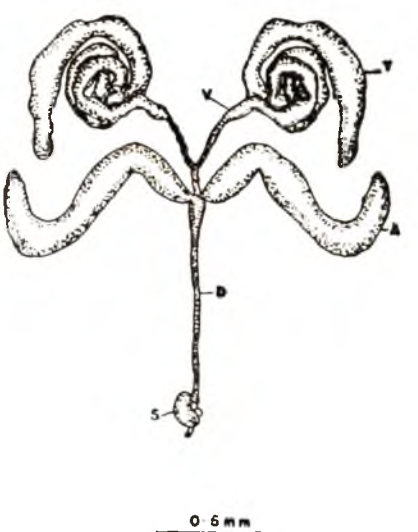

Fig. 5. Male Reproductive organs. A — Accessary gland; D — Anterior ejaculatory duct; S — Ejaculatory bulb; T — Testes; V — Vas deferens.

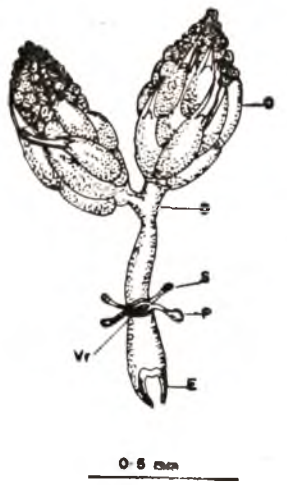

Fig. 6. Female Reproductive organs. D — oviduct; E — Egg guide, O — Ovary; P—Parovaria, S — Spermatheca, Vr = Ventral receptacle.

holotype. The holotype and some paratypes are deposited in the Department of Zoology, University of Mysore, Manasa Gangothri, Mysore. Other paratypes are also deposited in the department of Biology, Tokyo, Metropolitan University, Setagayaku, Tokyo, Japan, Zoological survey of India, Calcutta and some will be deposited in the Indian Agricultural Research Institute, New Delhi.

Taxonomic status: The nature of the banding pattern of abdominal tergites, egg with 2 filaments, presence of posterior pair of malpighian tubules which are free and the type of puparia warrant its inclusion in the *melanogaster* species group of sub genus *Sophophora.* The characters like yellowish abdomen with distinct apical bands, presence of sex-combs in male along the entire length of metatarsal and second tarsal segments, secondary surstylus with curved black medial teeth, permit its inclusion in the *montium* sub group (Bock and Wheeler, 1972).

Relationships and remarks: Okada (personal communication, February 1980) has pointed out that the new species resembles *Drosophila barbare* Bock and Wheeler 1972, in the abdominal banding pattern and in general features of periphallic and phallic organs, However, the two species differ from one another in the number of teeth in the sex-combs, in the structure of periphallic and phallic organs. Recently Tsacas and David (1977) distinguished a group of nine species of the *montium* sub group allied to *Drosophila kikkawai* and named this cluster of species as *kikkawai* complex. (D. Kikkawai, Burla, 1954; *D. barbare* Bock and Wheeler, 1972; *D. lini* Bock and Wheeler, 1972; *D. pennae* Bock and Wheeler, 1972; *D. brevis* Parshed and Singh, 1971; *D. leontia* Tsacas and David, 1977; *D. diplacantha,* Tsacas and David, 1977; *D. anomelani*, Ready and Krishnamurthy, 1973; *D. mysorensis* Reddy and Krishna Murthy, 1970). The new species described here shows the presence

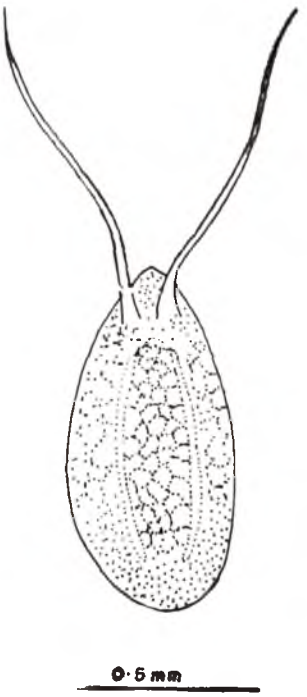

Fig. 7. Egg.

of essential features of *kikkawai complex* and can be tentatively included in this complex. However, on comparison with the known species of this complex it was found that the new species differs from them in the number of teeth in the sex-combs, number and arrangement of lateral teeth and in the absence of median long bristles above the ventro-median cluster of teeth in primary surstylus, in having short sub median spines and in the absence of serrated dorsal margin of posterior parameres. Thus the presence of the combination of the above mentioned characters are unique to this species and are not found in any known species of *kikkawai* complex of the *montium* sub group. Therefore it deserves the status of a new species in this complex.

The new species can be cultured in the laboratory with standard wheat-cream agar medium. The specific name *Drosophila cauve ii* is coined to denote the river Cauvery, originating from Coorg district and on the banks of which it was collected for the first time.

Acknowledgements:—The authors are grateful to Professor N. B. Krishna Murthy, Head of the Department of Zoology, Manasa Gangothri, University of Mysore, Mysore, for providing necessary facilities and constant encouragement to carry out the work. We are highly thankful to Professor T. Okada, Tokyo Metropolitan University, Setagayaku, Tokyo, Japan, for his help in confirming the identification and to M. Rajendra for the preparation of drawings. One of us (NM) is thankful to the University of Mysore for awarding the Teacher Fellowship under the Faculty Improvement Programme.

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THE FUNCTIONAL RESPONSE OF *COCCINELLA SEPTUMPUNCTATA* LINN., A COCCINELLID PREDATOR OF MUSTARD APHID, *LIPAPHIS ERYSIMI* KALT.

T. B. SINHA, RANJAN K. PANDEY, RAJENDRA SINGH,
C. P. M. TRIPATHI & ARVIND KUMAR

Entomological Laboratory (Aphid-biocontrol Unit), Department of Zoology,
University of Gorakhpur, Gorakhpur, India - 273 001

(Received 18 October 1980)

The present work elucidates functional response of the grub of *Coccinella septumpunctata* showing non-linear relationship between the amount of consumption and the density of *Lipaphis erysimi*. *C. septumpunctata* consumed 20 aphids/predator at the prey population of 20 aphids, but consumed more aphids (349±26.8 aphids/predator) at a density of 1600, during the same period (24 hours). Such response of *C. septumpunctata* indicates its searching capacity which increases with prey population, reflecting its utility as a bioagent of mustard *(Brassica campestris)* aphids.

(Key words: Coccinella septumpunctata, Lipaphis erysimi, predator, prey, functional response)

INTRODUCTION

Lipaphis erysimi KALT., a major pest of an important oilseed crop mustard *(Brassica campestris* LINN.*)*, is reported to damage the crop annually up to 87.9% (PRADHAN *et al.*, 1960). Like other aphids this species is also attacked by the several natural enemies, important being the predators and parasitoids. Amongst the predators, coccinellids have proved their applicability as bioagents in the suppression of their prey population (HAGEN, 1962; ATWAL & SETHI, 1963). The grubs of the beetle, *C. septumpuntata* consume more aphids than adults (HAMALAINEN, 1977) and have been reported to play an important role in suppressing and regulating the aphid population (SHANDS & SIMPSON, 1972; HAMALAINEN *et al.*, 1975).

The establishment of predation efficiency values for different predator-prey densities is a critical element in the study of their prey population interactions (KNIPLING & GILMORE, 1971). The predator may respond to increased prey density by increasing their own numbers (numerical response); or they may respond by increasing the number of prey that each individual destroys (functional response) (SOLOMON, 1949). The latter response is essential for clear understanding and proper approach to the modelling of prey-predator interactions (HUFFAKER *et al.*, 1971) and is considered to be of central importance (HOLLING, 1966); and is basically of three types (see SINGH *et al.*, 1979). In this paper an attempt has been made to obtain information about the functional response of *C. septumpunctata*.

MATERIALS AND METHODS

Aphids were reared in the laboratory on the fresh foliage of *Brassica campestris* (host plant), by adopting the technique of WHEELER

(1923). *C. septumpunctata* was reared on the same aphid species by the technique of SINGH & MALHOTRA (1979). Culture was maintained at 25°C ± 2 and 75% RH ± 5.

All the experiments were performed in petri dishes 15 × 2 cm having moistened filter paper at the bottom. Counted number of aphids (mostly second and third instars) were placed on a standard sized (10 × 5 cm) fresh and tender mustard leaf which was then placed over the filter paper. The aphids were then allowed to settle. Twenty four hours starved third instar grubs of *C. septumpunctata* were utilised as predators. The functional response was observed at varying aphid densities, *viz.*, 20, 40, 80, 100, 200, 400, 800 and 1600. In each set a single predator was released. The experiment was run for 24 hours, thereafter, the number of unconsumed aphids left over in the petri dishes were counted and calculated for consumed ones. The experiment was replicated ten times. Regression analysis and t-test were applied to test the significance.

RESULTS AND DISCUSSION

The functional response of the grub of *C. septumpunctata* is of *type 2* of HOLLING (1959), and can be explained by a linear relationship between log number of prey consumed and log of initial number of prey (log Y = 1.10 log X—0.40, r = +0.989, P < 0.001), and between percentage of prey consumed and log of initial number of prey (Y = 132.44—31.74 log X, r = —0.974, P < 0.001) (Fig. 1). Initially the number of prey consumption increases whereas percentage of prey consumption decreases till the number of prey increases up to 800 thereafter, the number of prey consumption tends to level, whereas, the percentage of prey consumption declines throughout (Fig. 2, Table 1). The grub consumed 100% of aphids (prey) at a density of 20 and only 22% at a density of

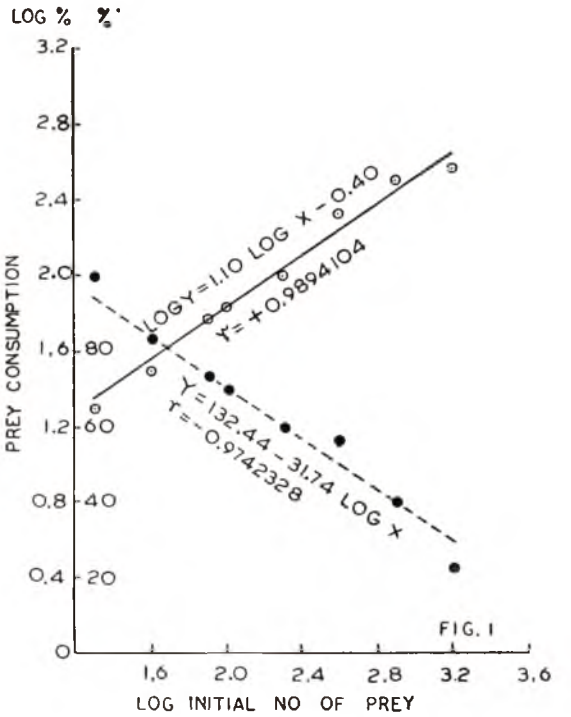

Fig. 1. Relatioship between the log. initial number of *Lipaphis erysimi* on the % (---------) and the log of their consumption (————)acused by individuai *Coccinella septumpunctata.*

TABLE 1. The number of prey consumed by *Coccinella septumpunctata* at various initial number of *Lipaphis erysimi*.

Density of prey *(L. erysimi)*	Average number of prey consumption (± S E)	Average percentage of prey consumption (± S E)
20	20 ± 0	100 ± 0
40	33 ± 1.9	82.5 ± 4.9
80	60 ± 1.8	74.1 ± 2.8
100	70 ± 1.9	70.0 ± 1.9
200	120 ± 2.6	60.0 ± 1.3
400	220 ± 9.8	57.5 ± 0.9
800	313 ± 9.6	39.3 ± 1.2
1600	349 ± 8.5	21.9 ± 0.5

1600 aphids, with the maximum number varying between 800 and 1600. The present findings evidence that the prey density has a significant influence on the rate of prey consumption which conform to the *type 2* model of HOLLING (1959).

Recently, MARKS (1977) has reported that the grub of *C. septumpunctata* is unable to detect its prey either by vision or by olfaction and the search is random (MURDOCH & MARKS, 1973). Probability of contact with the prey at higher density would tend to increase per unit area. However, HAGEN & BOSCH (1968) reported that the aphidophagous coccinellids are attracted to high prey population.

During the field collection it was experienced that in most of the fields where aphids were absent even then the grubs of predator were present, indicating that the predator is initially attracted to their prey habitat and later to prey proper.

The functional response of *C. septumpunctata* resembles to that of *type 2* of HOLLING (1959) which is considered to be the typical functional response (HASSELL *et al.*, 1976). Though analysis of models containing one of the three types of the functional responses indicated that *type 3* response provides stability (HASSELL & MAY 1973), the presence of *type 2* functional response, as evident in the present case can by no means should be used to underscore a potential bioagent as incapable for the regulation of prey population, because in the establishment of prey-predator

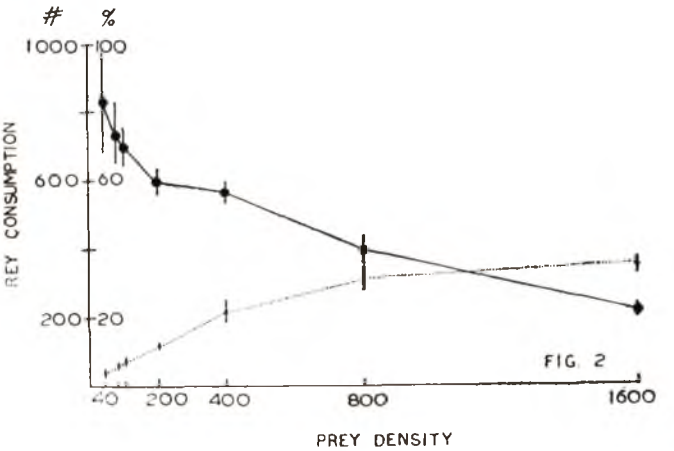

Fig. 2. Relationship between the initial number of *Lipaphis erysimi* on the average number (.....) and percentage (————)consumption of *Lipaphis erysimi* caused by individual *Coccinella septumpunctata*.

interactions, it is the numerical response of the predator which plays greater role (HUFFAKER *et al.*, 1976). The study of the latter response is in progress.

Acknowledgement:—We wish to thank Prof. G. S. SHUKLA, Head of the Department of Zoology, University of Gorakhpur for providing research facilities.

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STUDY OF THE GENUS *APHIDIUS* (HYMENOPTERA: APHIDIIDAE) OF INDIA

D. N. RAYCHAUDHURI, S. C. PODDAR & D. RAYCHAUDHURI

Aphid Research Unit, Entomology Division, Department of Zoology, Calcutta University, Calcutta, India 700 019

(Received 11 October 1980)

Eight *Aphidius* species available in India as parasites of aphids have been considered in this paper.

(*Key words: Aphidius* species of India)

In nature aphids are attacked by a large number of natural enemies which can be grouped as parasites and predators. For sometime past studies on the natural enemies of aphids occurring in India have been undertaken and as a result quite a large number of parasites and predators have been recorded. Among the parasites it is noticed that members of the genus *Aphidius* of the family Aphidiidae are frequently met with in the field. It has therefore been thought desirable to provide a comprehensive account of the members of the genus *Aphidius* available in India. In this connection it may be pointed out that Stary and Schlinger (1967 , made a revisionary study of the family Aphidiidae in respect of far East Asia. Takada (1968), made a similar study for Aphidius species available in Japan. Stary' (1973), reviewed the *Aphidius* species of Europe and subsequently in 1976 he gave an account of *Aphidius* species available in Mediterranean countries.

In the present communication eight determined species so far known from India have been dealt with. Those reported as *Aphidius* sp. have not been considered here since their specific identity has not been definitely determined. The distribution of the genus *Aphidius* in India has been shown in the map (Fig. 5). Material of these species have been collected from different places in India and are in the collection of the Entomology Laboratory, Department of Zoology, Calcutta University.

Genus *Aphidius* Nees

Aphidius Nees (1818), Nova Acta Acad. Caes. leop. Carol. 9: 302.

Type-species: *Aphidius avenae* Haliday, 1834.

The genus *Aphidius* differs from other genera of the family Aphidiidae by characters of wing venation, viz. presence of radial abscissa one and two, interradial vein, intermedian and median veins, incomplete pterostigmal cell, fused radial and median cells; of propodeum. Completely areolated; and of ovipositor sheath; sparsely hairy and apex blunt.

In the family Aphidiidae the members of the genus *Aphidius* are most frequently encountered. So far, eight species are

Abbreviations used in the text: F_1 and F_2 Flagellar segments 1 and 2; radial abs_1 and abs_2 —Radial abscissa 1 and absissa 2.

known from India and all are known to parasitize the members of subfamily Aphidinae.

KEY TO THE SPECIES FOUND IN INDIA

Female:

1. Pterostigma at most upto about 4 times (3.2 to 3.9) as long as its maximum width...2
— Pterostigma more than 4 times (4.8 to 5.6) as long as its maximum width 5
2. Pterostigma always more than 3.5 times as long as its maximum width 3
— Pterostigma less than 3.5 times as long as its maximum width 4
3. Antennae 18-segmented, pterostigma about 3.8 times as long as its maximum width. Anterolateral area of tergite 1 with 10 costulae on an average; tergite about 2.4 times as long as wide at level of spiracles ..... *rosae* Haliday
— Antennae 19—20 segmented. Pterostigma about 4 times as long as its maximum width ..... *smithi* Sharma and Subba Rao
4. Anterolateral area of tergite 1 with 9 costulae on an average; antennae 16-segmented; pterostigma about 3.2 times as long as its maximum width. Tergite 1 nearly 2.3 times as long as wide at level of spiracles ..... *uzbekistanicus* Luzhetzki
— Anterolateral area of tergite 1 with 7 costulae on an average. Pterostigma about 3 times as long as its maximum width. Antennae 17-segmented. Tergite 1 about 2 times as long as wide at level of spiracles..... *absinthii* Marshall
5. Anterolateral area of tergite 1 costate about 2.5 times as long as wide at level of spiracles. Pterostigma about 5 times as long as its maximum width. Anterolateral area of tergite 1 with 4 costae..... *colemani* Viereck
— Anterolateral area of tergite 1 costulate..... 6
6. Antennae 15-segmented. Pterostigma about 5.6 times as long as its maximum width. Tergite 1 about 2.5 times as long as wide at level of spiracles, anterolateral area of tergite 1 with 7 costulae on an average..... *matricariae* Haliday
— Antennae with more than 15-segments ...7
7. Pterostigma about 5.5 times as long as its maximum width. Tergite 1 about 2.8 times as long as wide at level of spiracles. Antennae 19-segmented ..... *urticae* Haliday
— Pterostigma about 4.8 times as long as its maximum width. Tergite 1 about 3 times as long as wide at level of spiracles. Antennae 18-segmented ..... *similis* Stary and Carver (Ms. name)

1. Aphidius absinthii Marshall

Aphidius absinthii Marshall, 1896, Spec. Hym. Eur. Alg., 5: 605 (♂).

Aphidius commodus Gahan, 1927, Proc. U. S. Nat. Mus., 70: 3 (♀ ♂).

Aphidius absinthii Stary, 1962, Ent. Tidskr. 82: 218.

Measurements of one female in mm.

Head: Inter-tentorial line 0.09; tentorio-ocular line 0.05; interocular line 0.34; facial line 0.38; socket diameter 0.06; socket ocular line 0.03; width of gena 0.07; transfacial line 0.20; width of head 0.45; flagellar segments F_1 length 0.11, breadth 0.03; F_2 length 0.11, breadth 0.03.

Wing: Pterostigma length 0.52, breadth 0.16; metacarp length 0.30; radial abs_1 0.16, abs_2 0.22; tergite 1 length 0.34, breadth 0.16.

The Indian material differs in the following from the description of *absinthii* given by Stary (1973) and Takada (1968);

Female: Antennae 17-segmented; F_1 and F_2, each 3.6 times as long as broad. Tentorio-ocular line about 1/2 to the intertentorial line.

Wing: Pterostigma about 3.2 times as long as broad; metacarp about 3/5 of pterostigma; radial abscissa 1 shorter than abscissa 2. Tergite 1 about 2 times as long as broad at level of spiracles.

Mummy: Light brownish.

Material examined: Four females.

TABLE 1. Parasite-host aphid-food plant-locality catalogue.

Parasite	Host species	Aphid Tribe	Food plant	Locality	Period of collection
Aphidius absinthii Marshall	*Macrosiphoniella pseudoartemisiae*	Macrosiphini	*Artemisi vulgaris*	*Kalimpong (West Bengal)	April
	M. sanborni	,,	*Chrysanthemum* sp.	*Dehradun (Uttar Pradesh)	October
	M. yomogifoliae	,,	*Artemisia* sp.	Gaylzing (*c* 1768 m) (Sikkim)	December
A. colemani Viereck	*Aphis gossypii* group	Aphidini	*Vitis* sp	*Upper Shillong (Meghalaya)	January
	Aphis sp.	,,	Tobacco plant	*Bangalore (Karnataka)	Not known
	Hyalopterus pruni	,,	*Prunus cerasus*	Ghaspani (*c* 304 m) (Nagaland)	March
	Rhopalosiphum maidis	,,	Unidentified plant	*Bangalore (Karnataka)	Not known
A. matricariae Haliday	*Aphis gossypii* group	,,	*Hibiscus esculentus*	Gangtok (*c* 1675) (Sikkim)	December
	A. spiraecola	,,	*Bidens pilosa*	-do-	February
			Gynura angutosa	-do-	February
	Brachycaudus cardui	Macrosiphini	*Carduus delbergii*	*Perimaha t,Srinagar (Jammu & Kashmir) Sfate	September
	B. helichrysi	,,	*Ageratum conyzoides*	Gangtok (*c*1675 m) (Sikkim)	February
				Namchi (*c* 1666m) (Sikkim)	December
	Brachycaudus sp.	,,	*Carduus* sp.	*Kangan, Kashmir (Jammu & Kashmir State	November
	Brevicoryne brassicae	Macrosiphini	*Brassica* sp.	*Shillong (Meghalaya)	April
	Capitophorus indicus	,,	*Polygonum chinense*	-do-	January
	Diphorodon cannabis	,,	*Cannabis sativa*	*Manashbal, Kashmir (Jammu & Kashmir)	September
	Diphorodon sp.	,,	,,	*Kupwara, Kashmir (Jammu & Kashmir State	September
	Lipaphis erysimi	,,	*Brassica napus*	*Shillong (Meghalaya)	June
	Myxus dycei	,,	Unidentified plant	-do-	December
	M. persicae	,,	*Brassica napus*	Melli (*c* 235 m) (Sikkim)	December

TABLE 1. (Contd.)

Parasite	Host Species	Aphid Tribe	Food plant	Locality	Period of collection
			Unidentified pl[illegible]	*Shillong (Meghalaya)	March
	Myzus sp.	,,	A plant of Rubiaceae	-do-	January
A. rosae Haliday	*Macrosiphum rosae*	,,	*Rosa* sp.	Kalimpong (*c*1400m) (West Bengal)	April
			Rosa sp.	Gangtok (*c*1665 m) (Sikkim)	May
	M. (Sitobion) rosaeiformis	,,	*Rosa* sp.	Almorah (*c* 1600 m) (Uttar pradesh)	December
A. similis Stary'&Carver	*Aphis spiraecola*	Aphidini	*Bidens pilosa*	Gangtok (*c* 1675m) (Sikkim)	February
	A. gossypii complex	,,	*Hibiscus esculentus*	-do-	December
	Brachycaudus helichrysi	Macrosiphini	*Gynura angutosa*	Gangtok (*c* 1675m) (Sikkim)	December
			Ageratum conyzoides	Namchi (*c* 1666m) (Sikkim)	December
	Myzus persicae	,,	*Brassica napus*	Melli (*c* 235 m) (Sikkim)	December
			Solanum	Gangtok (*c* 1675) (Sikkim)	February
A. smithi Sharma and Subba Rao	*Acyrthosiphon pisum*	Macrosiphini	*Lathyrus odoretus*	*Kaika (Punjab)	Not known
		,,	*Pisum sativum*	*Dehradum, Uttar Pradesh, Jullundar, Punjab, Kalimpong, West Bengal	,,
A. urticae Haliday	*Pseudoacyrthosiphon holsti*	,,	*Rhododendron* sp.	Darjeeling (*c*2000m) (West Bengal)	May
A. uzbekistanicus Luzhetzki	*Rhopalosiphum maiddis*	Aphidini	*Hordeum vulgare*	Ranipul (*c* 1060m) (Sikkim)	November
	Macrosiphum (Sitobion) sp.	Macrosiphini	*Triticum aestivum*	Aligarh (*Uttar Pradesh)	January
			Avena sativa	Aligarh *(Uttar Pradesh	April
			Penisetum flaccidum	*Shankrachara Hill lock, Srinagar (Jammu & Kashmir) State	October

Altitudes of the localities marked * were not available from the literature.

Host-aphid species in India: *Macrosiphoniella pseudoartemisiae* (Shinji), *M. sanborni* (Gillette), *M. yomogifoliae* (Shinji).

Distribution: India: Sikkim, Uttar Pradesh, West Bengal; Crimea; France; Hongkong; Italy; Japan; Korea; Spain; Taiwan; Transcaucasia (Gruzya, Azerbaidan): Turkey.

The parasite species appears to be restricted to members of only one genus of the tribe Macrosiphini.

2. Aphidius colemani Viereck.

Aphidius colemani Viereck, 1912, Proc. U. S. nat. Mus., 42: 141 (♀ ♂).

Aphidius platensis Brethes, 1913, Ann. Mus. Nat. Hist. Nat. B. Aires, 24: 41 (♀).

Aphidius hubrichi Brethes, 1913, Ann. Mus. Nat. Hist. Nat. B. Aires, 24: 41 (♀ ♂).

Aphidius porteri Brethes, 1915, Ann Zool. Apl. 2: 13 (♂).

Aphidius aphidiphilus Benoit, 1955, Ann Mus. Congo Tervuren Ser. 8, Zool., 36: 349 (♀ ♂).

Aphidius leroyi Benoit, 1955, Ann. Mus. Congo Tervuren Ser. 8, Zool., 36: 350 (♀).

Aphidius transcaspicus Telenga, 1958 Uzbek. Biol. Zurn., 2: 55 (♀ ♂).

Measurements of one female in mm:

Head: intertentorial line 0.10; tentorio ocular line 0.03; inter-ocular line 0.34; facial line 0.33; socket diameter 0.06; socket ocular line 0.03; width of gena 0.05; transfacial line 0.18; width of head 0.47; flagellar segments F_1 length 0.10, breadth 0.04; F_2 length 0.10, breadth 0.04:

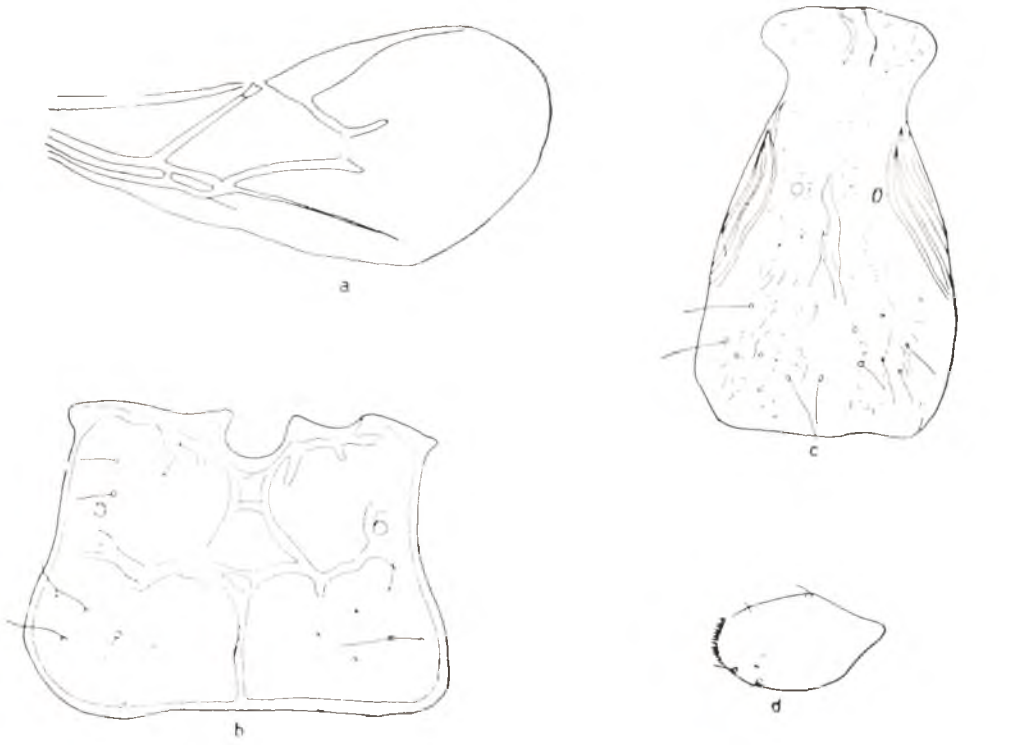


Fig. 1. *Aphidius colemani* ♀, a. Forewing, b, Propodeum, c. Tergite 1, d. Ovipositor sheath.

Wing: Pterostigma length 0.45, breadth 0.09; metacarp length 0.30; radical abs_1 0.15, abs_2 0.09; tergitel length 0.31, breadth 0.12.

The Indian material differs from the description of the species by the following:

Female: Clypeus with 11 hairs; tentorio-ocular line about 1/3 of intertentorial ine. Eyes small and rounded. Antennae broken, F_1 and F_2 about 2.5 times as long as broad. Ocellar triangle right.

Propodeum (Fig. 1b) upper areola with 8 and lower with 4 hairs. Discs of areolae smooth.

Wing: (Fig. 1a): Pterostigma 5 times as long as broad; metacarp 2/3 of pterostigma; radial abscissa 2 about 2/3 to the radial abscissa 1.

Tergitel (Fig. 1c) about 2.5 times as long as broad at level of spiracles; central longitudinal carina short but distinct anterolateral area longitudinally costate with 4 costae, apical part rugose-crenus late with 14 long hairs. Spiracular tubercle-hardly visible with neighbourhood excavated, lateral margin of apical part slightly convex. Ovipositor sheath comparatively smaller (Fig. 1d).

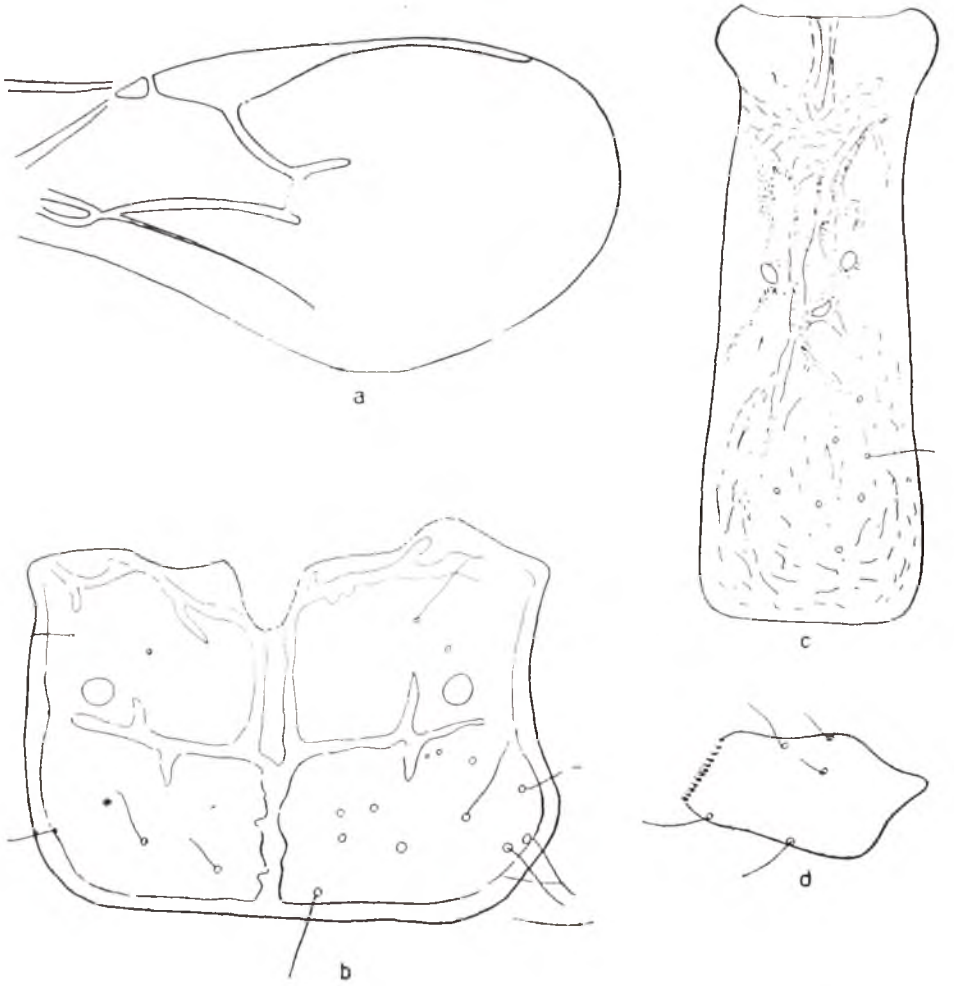


Fig. 2. *Aphidius similis* ♀ a. Forewing, b. Propodeum, c. Tergite 1, d. Ovipositor sheath

Male: Antennae 18 to 19-segmented wing: pterostigma about 4.4 times as long as broad; metacarp short than pterostigma, radial abscissa 2 about 2/3 to the radial abscissa 1. Propodeum and tergite 1 as in female.

Mummy: Light brownish.

Material examined: Three females and two males.

Host-aphid species in India : *Aphis gossypii* group, *Hyalopterus pruni* (Geoffroy), *Rhopalosiphum maidis* (Fitch), *R. nymphaeae* (Linnaeus).

Distribution: India: Karnataka, Meghalaya, Nagaland; Africa; America; Asia; Australia; Mediterranean countries; Pakistan.

The host species of the parasite belong to two genera in the tribe Aphidini.

3. Aphidius matricariae Haliday.

Aphidius (Aphidius) cirsii Haliday, 1834, Ent. Mag., 2: 101 (♀).

Aphidius (Aphidius) matricariae Haliday, 1834, Ent. Mag., 2: 103 (♀).

Aphidius (Aphidius) aurundinis Haliday, 1834, Ent. Mag., 2: 104 (♀).

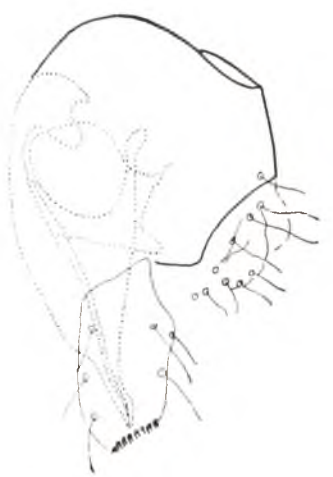


Fig. 3. *Aphidius matricariae* ♀, Genitalia.

Aphidius phorodontis Ashmead, 1889, Proc. U. S. Nat. Mus., 11: 662 (♀ ♂).

Aphidius chrysanthemi Marshall 1895, in Andre, Spec. Hym. Eur. Alg., 5: 591 (♀ ♂).

Aphidius polygoni Marshall, 1896, in Andre, spec. Hym. Eur. Alg., 5: 602 (♀ ♂).

Aphidius lychnidis Marshall, 1896, in Andre, spec. Hym. Eur. Alg., 5: 607 (♂)

Aphidius valentinus Quilis, 1931, EOS, Madrid, 7: 46 (♀).

Aphidius affinis Quilis, 1931, EOS, Madrid, 7: 48 (♀ ♂).

Aphidius aurundinis Haliday var. *obscuriforme* Quilis, 1931, EOS, Madrid, 7: 50 (♀).

Aphidius dyscritus Quilis, 1931, EOS, Madrid, 7: 65 (♀).

Aphidius merceti Quilis, 1931, EOS, Madrid, 7: 58 (♀ ♂).

Aphidius bandysi Quilis. 1934, EOS, Madrid, 10: 10 (♀).

Aphidius renominatus Hincks. 1943, Ent. mon. Mag., London, 179: 44 (n. name for *cirsii* Haliday, 1834, Nee Curtis, 1831).

Aphidus (Aphidius) nigriteleus Smith, 1944, Ohio State Univ. Contr. Zoo. Ent., 6: 61 (♀ ♂).

Measurements of one female in mm.

Head: Inter-tentorial line 0.06; tentorio-ocular line 0.02; inter-ocular line 0.14; facial line 0.30; socket diameter 0.05; socket ocular line 0.02; width of gena 0.04; transfacial line 0.13; width of head 0.37; flagellar segments F_1 length 0.09, breadth 0.03; F_2 length 0.09; breadth 0.03; wing: Pterostigma length 0.51 breadth 0.09; metacarp 0.33; radial abs_1 0.23, abs_2 0.19; $tergite_1$ length 0.23, breadth 0.09.

The Indian material differs in the following from the description of *matricariae* given by Stary (1973):

Female: Antennae 15-segmented. Clypeus with 8 long hairs. Tentorio-ocular line about 1/3 of intertentorial line. Propodeum: upper areola with 10 and lower with 4 long hairs: discs of areolae smooth. Wing: Pterostigma about 5.6 times as long as broad; metacarp 2/3 of pterostigma; radial $abscissa_1$ longer than $abscissa_2$.

Tergite 1 about 2.5 times as long as broad at level of spiracles; central longitudinal carina long, distinct and bifurcated apically; apical part rugose with 9 long hairs. Genitalia as in Fig. 3.

Male: Antennae 15 or 18—segmented. wing: pterostigma about 5.7 times as long as broad, metacarp shorter than pterostigma; radial abscissa 1 and 2 about equal Propodeum and tergite 1 as in female.

Mummy: Yellowish.

Material examined: Six females and three males.

Host-aphid species in India: *Aphis gossypii* group, *A. spiraecola* Patch, *Brachycaudus cardui* (L.), *B.helichrysi* (Kalt.), *Brevicoryne brassicae* (L.), *Capitophorus indicus* Ghosh and Raychaudhuri, *Diphorodon cannabis* (Passerini), *Lipaphis erysimi* (Kalt.), *Myzus dycei* Carver, *M. persicae* (Sulzer), *Shinjia pteridifoliae* (Shinji).

Distribution: India: Jammu and Kashmir State, Meghalaya, Sikkim; Algeria; Bulgaria; Corsica, Cyprus; France; Greece; Gruzya ; Iraq; Israel; Italy; Portugal; Sardegna; Sicily; Spain; Turkey.

From the host range it appears that the parasite is polyphagous.

4. Aphidius rosae Haliday

Aphidius (*Aphidius*) *rosae* Haliday, 1834, Ent. Mag., 2: 97 (♀ ♂).

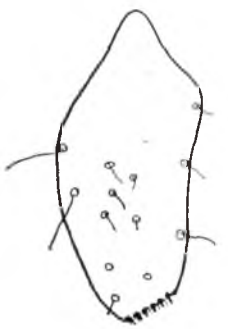


Fig. 4. *Aphidius urticae* ♀, Ovipositor sheath.

Aphidius rosarum Nees, 1834, Hym. Ichn. aff. Monogr., 1: 19 (♀ ♂).

Aphidius protaeus Wesmael, 1835, Nouv. Mem. Acad. Sci. Bruxelles, 9: 75 (♀ ♂).

Aphidius cancellatus Buckton, 1876, Mon. Brit. Aphid., 1: 111 (♀).

Measurements of one female in mm.

Head: Intertentorial line 0.12; tentorio-ocular line 0.05; inter-ocular line 0.34; facial line 0 41; socket diameter 0.06; socket ocular line 0.03; width of gena 0.06; transfacial line 0.23; head width 0.50; flagella F_1 length 0.11; breadth 0.04; F_2 length 0.11, breadth 0.04; wing: pterostigma length 0.62; breadth 0.16; metacarp length 0.34; radial abs_1 0.27; abs_2 0.20; tergite 1 length 0 37, breadth 0.15.

The Indian material differ in the following from the description of *rosae* given by Stary (1973).

Female: Antennae 18—segmented; flagellar segments: F_1 and F_2 each about 2.7 times as long as broad. Tentorio-ocular line about 1/2 of intertentorial line.

Propodeum: Upper areola with 14 and lower with 8 hairs. Wing: pterostigma 3.8 times as long as broad. Tergite 12.4 to 2.6 times as long as broad at level of spiracles; anterolateral area of tergite 1 with 19 costulae.

Male: Antennae 19—segmented, wing: pterostigma about 4.7 times as long as broad; metacarp shorter than pterostigma; radial abs_3 1/2 of abs_1. Propodeum and rergite 1 as in female.

Mummy: Yellowish.

Material examined: Five females and three males.

Host-aphid species in India: *Macrosiphum rosae* (L.), *M. (Sitobion) rosaeiformis* Das.

Distribution: India: Jammu and Kashmir State, Sikkim, Uttar Pradesh, West Bengal; Canary Isl., Corsica; Crimea; France; Greece; Gruzya; Iraq; Italy; Portugal; Sicily; Yogoslavia.

The parasite species is known to infest so far the members of the genus *Macrosiphum*.

5. Aphidius similis Stary and Carver (Ms. name)

Aphidius similis Stary and Carver, J. Aust. ent. Soc. (In press).

Measurements of one female in mm

Head : Inter-tentorial line 0.12; tentorio-ocular line 0.04; inter-ocular line 0.26; facial line 0.40; socket diameter 0.05; socket ocular line 0.03; width of gena 0.07; transfacial line 0.23; head width 0.51; flagella F_1 lengh 0.11, breadth 0.03; F_2 length 0.11, breadth 0.03; wing : pterostigma length 0.63, breadth 0.13; metacarp length 0.34; radial abs_1 0.24, abs_2 0.13; tergite 1 length 0.38, breadth 0.12.

Stary through personal communication has informed that the description of the species is in press. So detaild description is not provided here. However, the material determined as *similis* by Stary differ from other *Aphidius* species known from India in the following.

Female :

Head : Clypeus with 14 hairs; tentorio-ocular line 1/3 of inter-tentorial line. Antennae 18-segmented, F_1 and F_2, each about 3.6 times as long as broad. Ocellar triangle acute.

Propodeum (Fig.2b) : Central areola comparatively narrow, upper areola with 12 and lower with 4 hairs. Discs of areolae smooth. Wing (Fig.2a) : pterostigma about 4.8 times as long as broad; metacarp about 1/2 of pterostigma; radial abscissa$_2$ about 1/2 to the radial abscissa$_1$.

Tergite 1 (Fig. 2c) about 3.1 times as long as broad at level of spiracles; central longitudinal carina short but distinct; apical part rugose and with about 12 short hairs. Ovipositor sheath (Fig.2d) slender and longer.

Mummy : Light brownish

Material examined : Three females.

Host aphid species in India : *Aphis spiraecola* Patch, *A. gossypii* group, *Brachycaudus helichrysi* (Kalt.), *Myzus persicae* (Sulz.).

Distribution : India : Sikkim; Australia.

Polyphagism is noticed in case of this parasite.

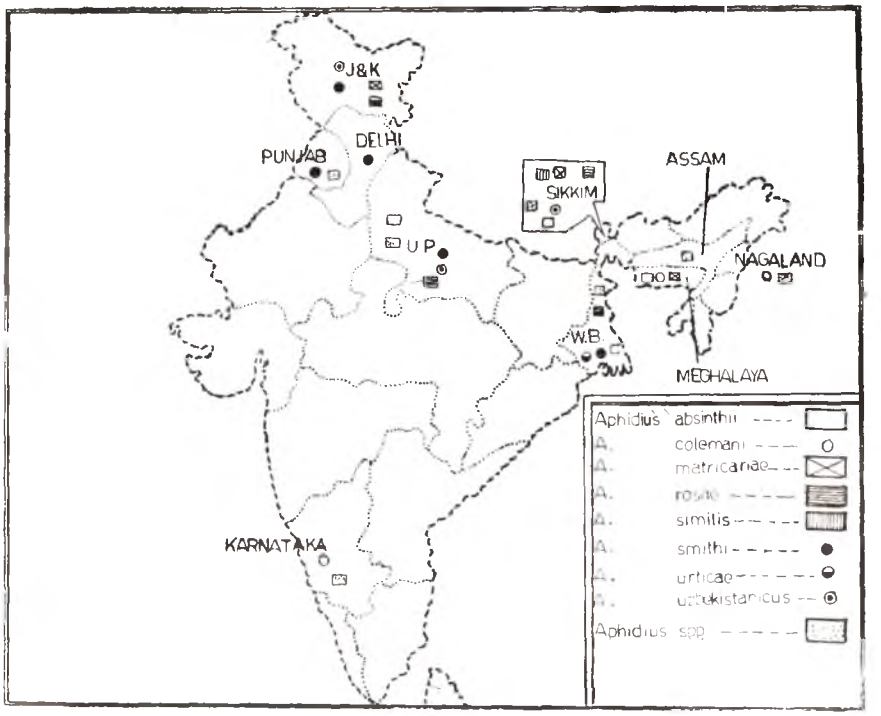
6. Aphidius smithi Sharma and Subba Rao

Aphidius (Aphidius) smithi sharma and Subba Rao, 1959, Indian J. Ent., 20 : 183 (♀ ♂).

Aphidius smithi Stary, 1973, Annot. Zool. bot. Bratislava, 84 : 55.

Measurements of one female in mm.

Head : Inter-tentorial line 0.11; tentorio-ocular line, 0.04; inter-ocular line 0.37; facial line 0.47; socket diameter 0.06; socket ocular line 0.03; width of gena 0.05; transfacial line 0.20; head



Map showing the distribution of *Aphidius* spp. in India.

width 0.54; flagella F_1 length 0.13; breadth 0.04; F_2 length 0.13, breadth 0.04; wing: pterostigma length 0.59, breadth 0.15; metacarp length 0.30; raidal abs_1 0.22, abs_2 0.22; tergite 1 length 0.35, breadth 0.12.

Mummy : Yellowish.

Host-aphid species in India ; *Acyrthosiphon pisum* (Harris).

Distribution : India : Delhi, Jammu and Kashmir state, Punjab. Uttar Pradesh, West Bengal; America.

7. Aphidius urticae Haliday

Aphidius (*Aphidius*) *urticae* Haliday, 1834 Ent. Mag., 2 : 100 (♀).

Aphidius longulus Marshall, 1896, in Andre, Spec. Hym. Eur. Alg., 5 : 560(♀).

Aphidius lonicerae Marshall, 1896, in Andre, Spec. Hym. Eur. Alg., 5 : 572 (♀ ♂).

Aphidius silenes Marshall, 1896, in Andre, Spec. Hym. Eur. Alg., 5 : 603 (♂).

? *Aphidius euphorbiae* Marshall, 1876, in Andre, Spec. Hym. Eur. Alg. 6 : 603 (♂).

? *Aphidius goidanichi* Quilis, 1932, Boll. Lab. Ent. Bologna, 5:50 (♀ ♂).

Aphidius ervi Haliday ssp. nigrescens Mackauer, 1962 Beitr. Eur., 12 : 642 (♀ ♂).

Aphidius rubi Stary, 1962, Bull. ent. Pologne, 32 :112 (♀ ♂).

Aphidius silvaticus Stary, 1962, Bull. ent. Polonge, 32 : 114 (♀ ♂).

Aphidius aulacorthi Stary, 1963, Acta. ent. Mus. Nat. Prague, 35 : 601, 603 (♀ ♂).

Aphidius caraganae Stary, 1963, Acta. ent. Mus. Nat. Prague, 35 :603 (♀ ♂).

Aphidius microtarsi Stary, 1963, Acta. ent. Mus. Nat. Prague, 35 : 605 (♀ ♂).

Measurements of one female in mm.

Head : Inter-tentorial line 0.12; tentoria-ocular line 0.07; inter-ocular line 0.38; facial line 0.44; socket dimeter 0.06; socket-ocular line 0.04; width of gena 0.07; transfacial line 0.23; head width 0.51; flagella F_1 length 0.11; breadth 0.04; F_2 length 0.11, breadth 0.04; wing ; pterostigma length 0.66, breadth 0.12; metacarp length 0.50; readial abs_1 0.31; abs_2 0.18: tergite 1 length 0.43, breadth 0.15.

The Indian material differ in the following from the description of *urticae* given by Stary (1973).

Female: Antennae 19-segmented; flagella F_1 and F_2, each 2.7 times as long as broad. Clypeus with 16 hairs. Ocular triangle acute.

Propodeum : central areola comparatively narrow ; upper areola with 25 and lower with 12 hairs. Wing : pterostigma 5.5 times as long as broad and longer than metacarp; radial abscissa 2 about 2/3 to the radial abscissa 1. Ovipostior sheath as in Fig. 4.

Mummy : Light brownish.

Material examined : One female.

Host-aphid species in India : *Pseudoacyrthosiphon holsti* (Takahashi).

Distribution : India West Bengal: Europe ; U. S. S. R.

8. Aphidius uzbekistanicus Luzhetzki

Aphidius behrani Quilis, 1931, EOS, Madrid 7 : 51 (♀ ♂).

Aphidius macropterus Quilis, 1931, EOS Madrid, 7 : 57 (♀).

Aphidius granarius Marshall var. paillot Quilis, 1931, EOS, Madrid, 7: 57 (♀ ♂).

Aphidius idivisus Quilis, 1931, EOS Madrid, 7 : 58 (♀ ♂).

Aphidius (Aphidius) uzbekistanicus Luzhetzki, 1960, Par. tlej. uzbekistana, 1 : 22 (♀ ♂).

Aphidius impressus Mackauer, 1965, Otsch. ent. Z., N.F., 12 : 347 (♀ ♂).

Measurements of one female in mm.

Head: Inter-tentorial line 0.12; tentorio-ocular line 0.03; inter-ocular line 0.29, facial line 0.41; socket diameter 0.06; socket ocular line 0.03; width of gena 0.06; transfacial line 0.22; head width 0.50; flagella F_1 length 0.11; breadth 0.04; F_2 length 0.11, breadth 0.04; wing: pterostigma length 0.58; breadth 0.18; metacarp length 0.33; radial abs_1 0.20, abs_2 0.19; tergite 1 length 0.37, breadth 0.16.

The Indian material differ in the following from the description of *uzbekistanicus* given by Stary (1973).

Female: Antennae 16—segmented; flagella F_1 and F_2 each 2.5 times as long as broad. Tentorio-ocular line 1/4 to the inter tentorial line.

Propodeum: Upper areola with 16 and lower areola with 8 hairs. Wing: pterostigma 3.2 times as long as broad; metacarp about 3/5 to the pterostigma; radial abscissa 1 and 2 about equal. Tergite 1, 2.3 times as long as broad at level of spiracles; anterolateral area of tergite 1 with 9 costulae.

Mummy: Golden.

Material: *examined*: Two females.

Host-aphid species in India: *Macrosiphum* (*Sitobion*) sp., *Rhopalosiphum maidis* (Fitch).

Distribution: India: Jammu and Kashmir state, Sikkim, Uttar Pradesh; Bulgaria; Corsica, Crimea; France; Italy; Sicily; Spain; Yugoslavia.

This species to a certain extent, exhibits polyphagism.

Acknowledgements:—The authors are grateful to the University Grants Commission, New Delhi for partly financing the work and to Dr. Petr. Stary, Czechoslovakia for kindly identifying the parasites. Mr. B. K. Agarwala of the Aphid Research Unit, Entomology Division, Department of Zoology deserves sincere thanks for manifold help.

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Entomon, 1982, *Vol.* 7, *No.* 1, *pp.* 23 *to* 30

FOUR NEW SPECIES OF PHYLLOCOPTINE MITES (ERIOPHYIDAE : ACARINA) FROM TAMIL NADU, INDIA

M. MOHANASUNDARAM

Cashew Research Station, Vriddhachalam, India 606 001

(Received 30 November 1981)

In this paper four new species of Phyllocoptine mites, viz., *Calacarus millingtoniae*, sp. nov., *Epitrimerus azimae* sp. nov., *Monotrimacus quadrangulari* gen et sp. nov. and *Notostrix flabelliferae*, sp. nov. have been described with adequate sketches. Among these the genus *Monotrimacus* is new to science and *Notostrix* Keifer is recorded for the first time from the Indian region. All the species have been adequately sketched.

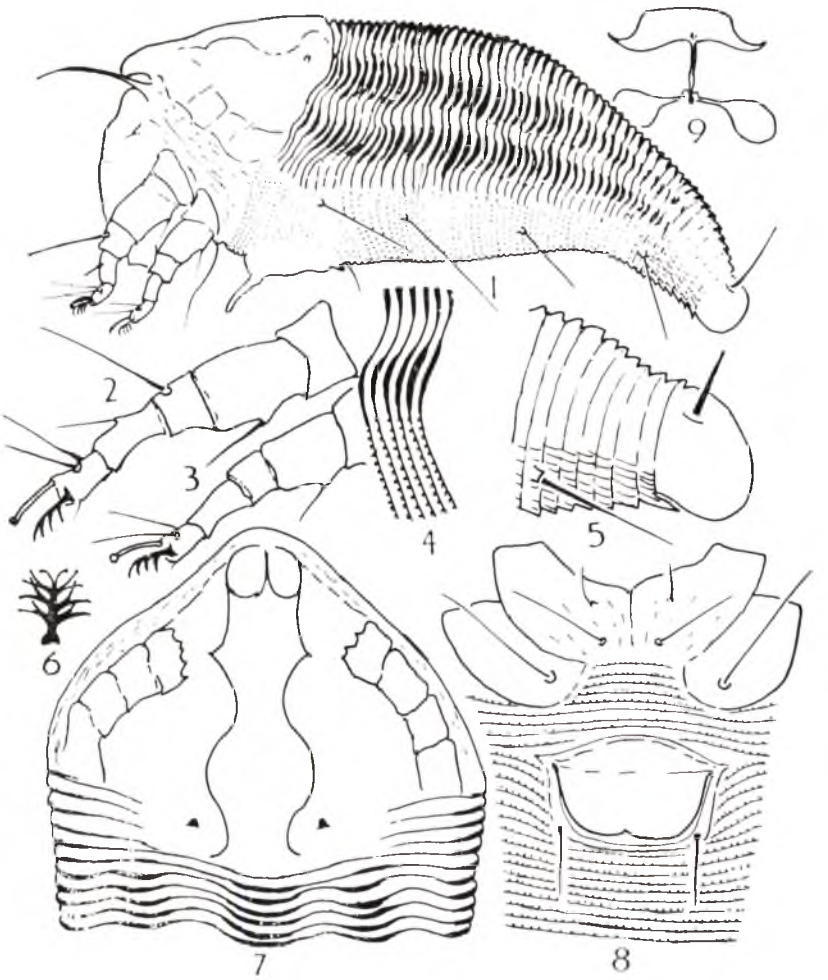
The types and paratype slides have been deposited in the Department of Agricultural Entomology Collections, Agricultural College and Research Institute, Tamilnadu Agricultural University, Coimbatore-641 300, India.

1. Calacarus millingtoniae sp. nov. (Figs. 1 to 9).

This species resembles *Calacarus alocasiae* Keifer (1978) in the shape of the admedian lines on the shield, but differentiated by the position of the dorsal tubercles, smooth hind coxae and the smooth female genital cover flap, apart from the measurements. This species is differentiated from *Calacarus brionesae* Keifer (1963) by the clear hind coxal area, smoother female genital cover flap and the absence of submedian lines on the shield.

Female: 210—220 μm[1] long, spindle shaped, light pink in colour with wax flakes on the shield and 5 wax bearing lines on the abdomen, 60 wide; rostrum 20.5 long, down curved, antapical seta 10 long. Shield 60 wide; 50 long, anterior shield lobe overhanging rostrum base; dorsal tubercles small, just away from rear shield margin, 25 apart dorsal setae absent. Anterior shield lobe with two apical cells, sides of shield with 4 cells on each side, median absent; admedians complete and wavy. Fore leg 33 long, tibia 8 long, tibial seta 5 long at middle; tarsus 6 long; claw 8 long with a knobbed tip; feather claw 4 rayed, rays branched. Hind leg 28 long, tibia 6 long; tarsus 6 long; claw 8 long. Foreleg with the femoral, patellar, tibial and tarsal setae while the hind leg with femoral and tarsal setae. Coxae with all three setiferous tubercles; coxal area with fine scorings in the fore coxae; seta I, 6 long; seta II, 16 long and seta III, 28 long. Abdomen with about 80 rings, tergites smooth with wax bearing areas forming dorsal and two lateral lines; sternites finely microtuberculate, microtubercles dot like; telosomal sternites with microstriations. Lateral seta 40 long on ring 12; first ventral seta 60 long on ring 30; second ventral seta 28 long on ring 53; third ventral seta 30 long on ring 8 from behind; caudal seta 70 long; accessory seta

[1] All measurements, unless otherwise stated, are in μm.



Calacarus millingtoniae ep. nov. (Figs. 1—9) 1. Side view of mite; 2 Left foreleg; 3. Left hind leg; 4. Side skin structure; 5. Side view of caudal end; 6. Feather claw; 7. Dorsal view of anterior end; 8. genitalia of female and coxae from below; 9. Internal female apodeme.

not visible. Female genitalia 26 wide; 20 long; genital seta 15 long; coverflap smooth.

Male: 200—210 long; 60 wide, genitalia 17 wide, genital seta 12 long.

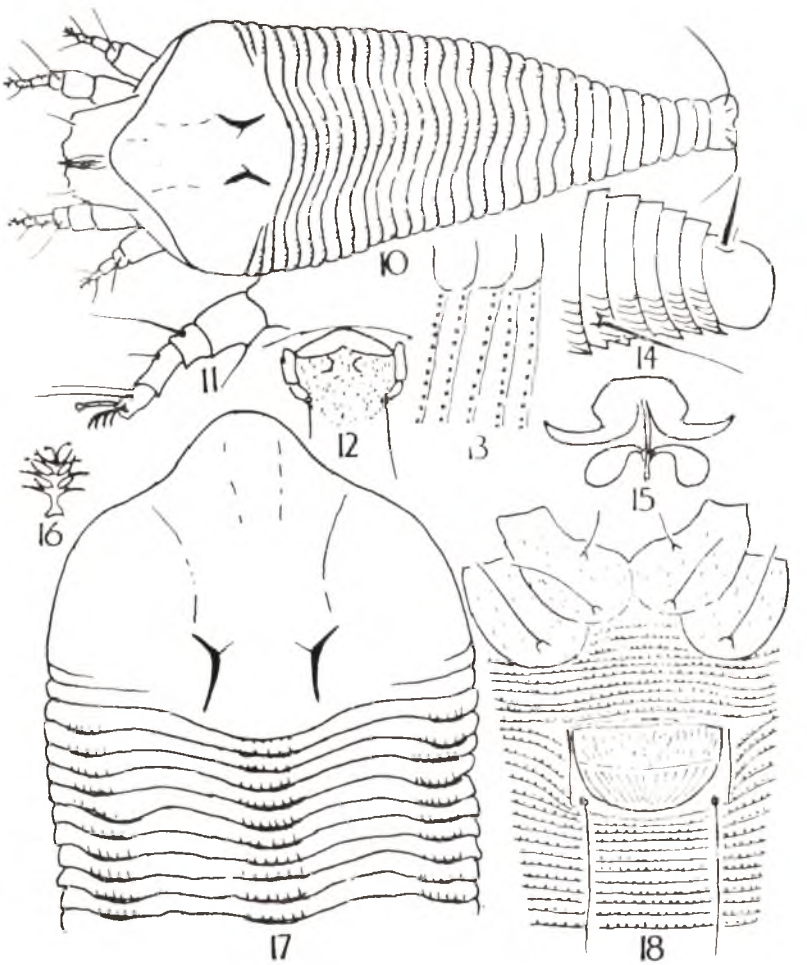
Types: A holotype slide with ♀♀ and 4 paratype slides with ♀♀ and ♂♂, India, Tamilnadu, Chidambaram. Coll. M. Mohanasundaram (No. 383).

Host: *Millingtonia hortensis* L. The mites are under surface leaf vagrants, causing slight rusting and crinkling of leaf.

2. Epitrimerus azimae. sp. nov. (Figs. 10—18).

This species is assigned to the genus *Epitrimerus* Nalepa based on the flattened body, a shallow furrow on each side of the dorsum, the tergites narrow, but smooth or mycrotuberculate, combined with the phyllocoptine feature of fewer tergites than the sternites. This species resembles *Epitrimerus lobeliae* Keifer (1962) by its 4 rayed feather claw, granular coxal area and female genital cover flap with two rows of scorings, but differentiated by the microtuberculation on the tergites, the longitudinally elongated dorsal tubercles, the minute dorsal setae apart from other features.

Female: Yellowish, dorsoventrally flattened, spindle shaped; 200—210 long; 65



Epitrimerus azimae (sp. nov. (Figs. 10—18)10. Dorsal view of mite; 11. Left fore leg; 12. Male genitalia, 13. Side skin structure; 14. Side view of caudal end; 15. Internal female apodeme; 16. Feather claw; 17. Dorsal view of anterior end; 18. Genitalia of female and coxae from below.

wide; rostrum 22 long, bent down; antapical seta 8 long. Shield 60 wide; 50 long with a broad lobe overhanging rostrum base, shield area clear except for a pair of broken lines in the anterior end and a pair of submedians connected to the dorsal tubercles. Dorsal tubercles diffuse, broadened longitudinally very characteristic, 20 apart; just away from rear shield margin; dorsal setae minute, 3 long, very thin pointing inward. Fore leg 33 long, tibia 8 long; tibial seta 5 long at basal 1/3, tarsus 6 long; claw 6 long knobbed at tip; feather claw 4 rayed. Hind leg 30 long; tibia 7 long, tarsus 5 long; claw 6 long, knobbed at tip. Coxae broadly joined, with all three setiferous tubercles; coxal area granular, seta I, 8 long; seta II, 16 long; seta III, 20 long. Abdomen with about 52—55 tergites, with fine elongate microtubercles on the middle and side ridges, troughs clear and with 80 sternites, finely microtuberculate, microtubercles dot like. Lateral seta 45 long on sternite 8; first ventral seta 55 long on sternite 27; second ventral seta 50 long on sternite 47, third ventral seta 25 long on sternite 7 from behind; caudal seta 50 long; accessory seta 2 long. Female genitalia 28 wide; 20 long, genital seta 10 long; cover flap basally with fine scorings and distally with about 18 lines.

Male: 190—200 long; 65 wide; genitalia 18 wide; genital seta 10 long.

Types: A holotype slide with ♀♀ and 5 paratype slides with ♂♂ and ♀♀ India, Tamilnadu, Vriddhachalam. Coll. M. Mohanasundaram (No. 389).

Host: *Azima tetracantha* Lamk. (Salvadoraceae). The mites are under surface leaf vagrants without causing any symptoms.

Monotrimacus new genus.

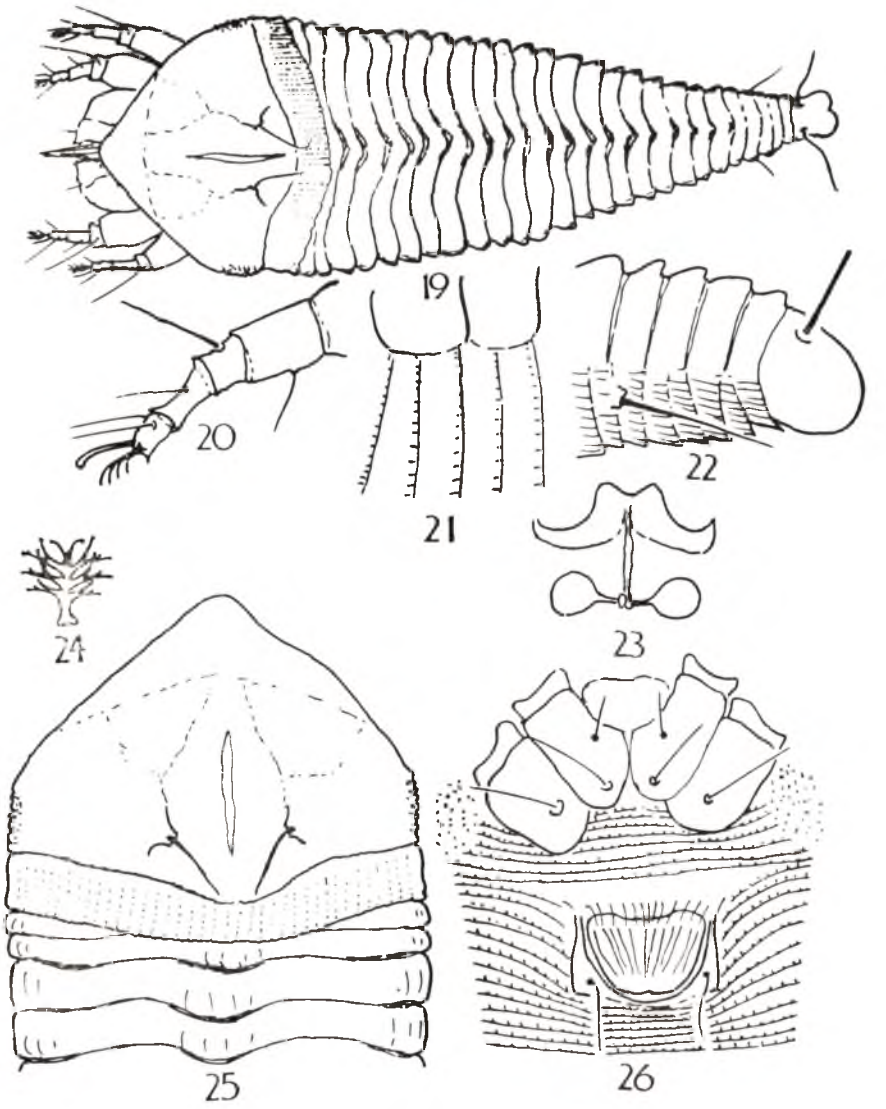
The new genus is near the genus *Ditrimacus* Keifer (1960) due to the presence of groove or pit on the shield but differentiated from it by the possession of a median pit or groove on the shield and the enlarged first abdominal tergite which is fused with the rear shield margin. The new genus is differentiated from *Epitrimerus* Nalepa by the same features of the mid dorsal pit or groove and the broad first abdominal tergite, fused with the rear shield margin and from *Calepitrimerus* Keifer apart from the above characters, by the absence of the middorsal ridge ending in a broad trough, since in the new genus the subdorsal ridges are not prominent.

Body fusiform in dorsal view, dorsoventrally flattened. Rostrum short, projecting down. All usual body and leg setae present with a simple feather claw. Cephalothoracic shield broad, anteriorly overhanging rostrum base; lateral posterior corners of shield granular. Dorsal tubercles away from rear shield margin, dorsal setae pointing upward and backward. A narrow median pit or invagination in the posterior 2/3 of the shield. Abdomen with broad smooth tergites, with fine microstriations in the middle and lateral aspects; and finely microtuberculate sternites. The first abdominal tergite broad, closely fused with the rear shield margin and with longitudinal scorings. Rest of the abdominal tergites with a median ridge and lateral troughs in the thanosomal segments. Female genitalia with longitudinal lines in two ranks on coverflap; internal apodeme normal.

Type species: *Monotrimacus quadrangulari* sp. nov.

3. Monotrimacus quadrangulari sp. nov. (Figs. 19—26).

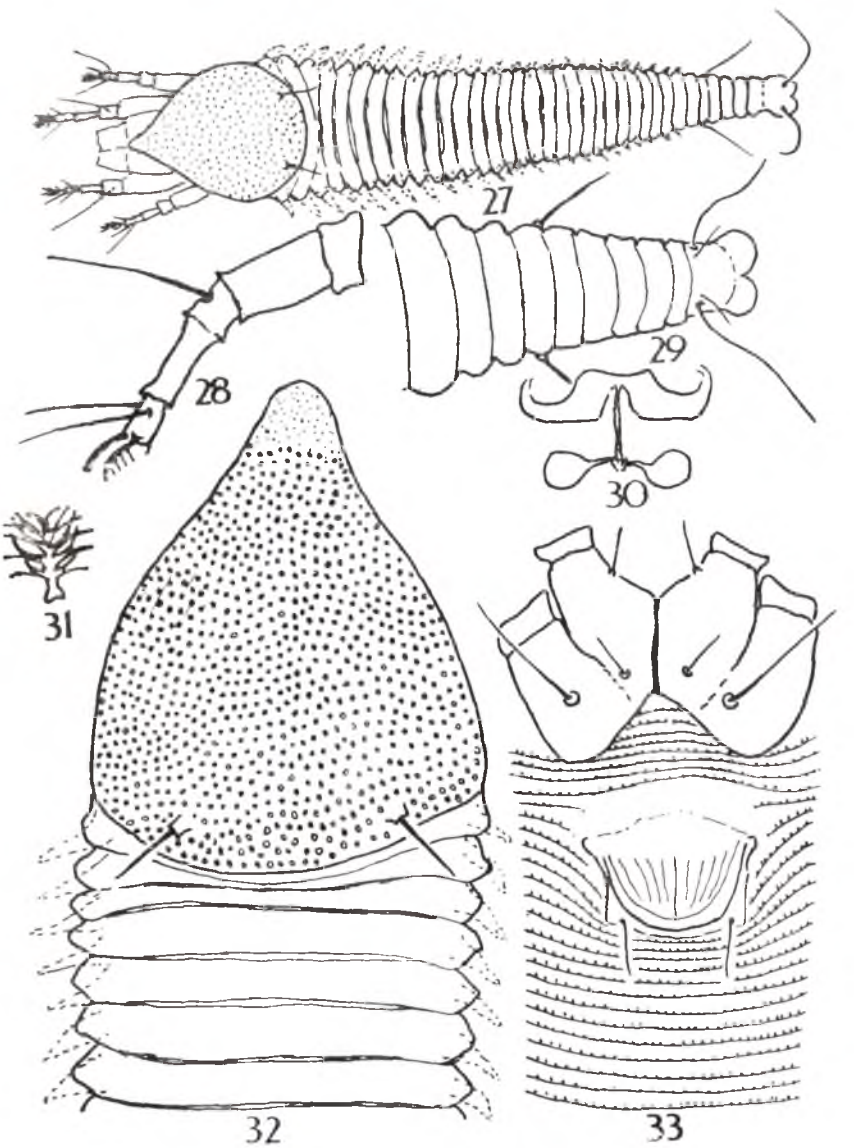
Female: Yellowish white, 160—170 long; 60 wide; rostrum 18 long; curved down; antapical seta 6 long. Shield area without lines but with light demarkations.



Monotrimacus quadrangulari sp. nov. (Figs. 19—26) 19. Dorsal view of mite; 20. Left foreleg; 21. Side skin structure; 22. Side view of caudal end; 23. Internal female apodeme; 24. Feather claw; 25. Dorsal view of anterior end; 26. Genitalia of female and coxae from below.

A clear groove in the middle of the shield in the posterior 2/3. Dorsal tubercles away from rear shield margin; 15 apart; dorsal setae 10 long, pointing upward and backward. Sides of shield clear except for the posterior corners which are heavily granular. Fore leg 30 long, tibia 9 long; tibial seta 5 long at basal 1/3; tarsus 5 long; claw 6 long, curved and knobbed at tip; feather claw 4 rayed. Hind leg 25 long, tibia 6 long; tarsus 5 long, claw 6 long. Both legs with the usual seta-

tion. Coxae with all three setiferous tubercles; coxal area clear; fore coxae fused with the suboral plate; seta I, 6 long; seta II, 10 long; seta III, 15 long. Abdomen with about 25 tergites, first abdominal tergite broad, closely fused with posterior margin of the shield; with fine longitudinal striations; rest of the tergites



Notostrix flabellifera sp. nov. (Figs. 27—33) 27. Dorsal view of mite, 28. Left fore leg; 29. Dorsal view of caudal end; 30. Internal female apodeme; 31. Feather claw; 32. Dorsal view of anterior end; 33. Genitalia of female and coxae from below.

with a middorsal ridge and two shallow troughs on either side; light microstriations on the middle and lateral aspects of the tergites; 62—65 finely microtuberculate sternites, microtubercles elongated in posterior segments, ending as microstriations in the telosomal sternites. Lateral seta 20 long on ring 10; first ventral seta 70 long on ring 24; second ventral seta 8 long on ring 38; third ventral seta 25 long on ring 6 from behind; caudal seta 50 long; accessory seta absent. Female genitalia 20 wide, 15 long, coverflap with 12—14 lines in two ranks, genital seta 12 long.

Male: Not known.

Types: A holotype slide and 6 paratype slides, all with ♀♀; India, Tamilnadu Vriddhachalam Coll. M. Mohanasundaram (No. 361).

Host: Cissus quadrangularis L. Mites found on tender short, flower buds and leaves without causing any symptoms.

4. Notostrix flabelliferae sp. nov. (Fig. 27—33).

This species resembles *Notostrix attenuata* Keifer (1963) in it general shape and length, but differentiated from it by the granular shield area; smooth coxal area, 5 rayed feather claw and the absence of the tibial and femoral setae in the fore leg. It also differs by the above characters from *Notostrix jamaicae* Keifer (1970) and is the third species to be described under the genus. The genus *Notostrix* Keifer is recorded for the first time from the Indian region and the new species is unique in that it possess wax fringes on the sides of the tergites; the shield area with granules like dot without any pattern of lines; and the absence of the femoral and tibial setae on fore leg. Both of the earlier known species have been recorded on *Cocos nucifera* Linn. the coconut palm while the present species was collected from *Borasus flabellifer* Linn. the palmyra palm.

Female: Worm like, 230—240 long; 50 wide; yellowish white in colour. Rostrum 20 long, curved forward; antapical seta 6 long. Shield 45 wide, 50 long, shield area without any lines but with uniformly placed dot like projections. Dorsal tubercles near rear shield margin, 23 apart; dorsal setae 8 long, pointing backward and outward. Fore leg 30 long tibia 10 long, tibial seta absent; tarsus 5 long, claw 5 long, slightly curved and knobbed at tip, feather claw 5 rayed; femoral seta absent, patellar and tarsal setae present. Hind leg 28 long with all usual setae, tibia 8 long; tarsus 5 long, claw 5 long, similar to fore claw. Coxae with all three setiferous tubercles, with a clear sternal line, coxal area clear; seta I, 10 long; seta II, 10 long; seta III, 30 long. Abdomen with 35 broad, smooth tergites, with a shallow dorsal trough running for 3/4 the length of the abdomen; tergites with wax fringes on the sides of each segment, 85—90 sternites, uniformly, finely microtuberculate. Lateral seta 12 long on ring 10; first ventral seta 50 long on ring 25; second ventral seta 15 long on ring 50; third ventral seta 30 long on ring 8 from behind; caudal seta 55 long; accessory seta 3 long. Female genitalia 15 wide, 10 long; genital seta 10 long; coverflap with 9 longitudiual lines.

Male: Not known

Types: A holotype slide and 3 paratype slides, all with ♀♀, India, Tamilnadu, Vriddhachalam, Coll. M. Mohanasundaram (No. 360).

Host: *Borasus flabellifer* Linn. (Palmae). Mites found in the folds of tender unopened leaves.

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STUDIES ON ERIOPHYID MITES (ACARINA : ERIOPHYOIDEA) OF INDIA. VIII. DESCRIPTION OF NEW SPECIES OF *CALEPITRIMERUS* KEIFER FROM WEST BENGAL AND BIHAR

S. CHAKRABARTI & ASHOK K. DAS

Department of Zoology, University of Kalyani, Kalyani, West Bengal, India 741 235

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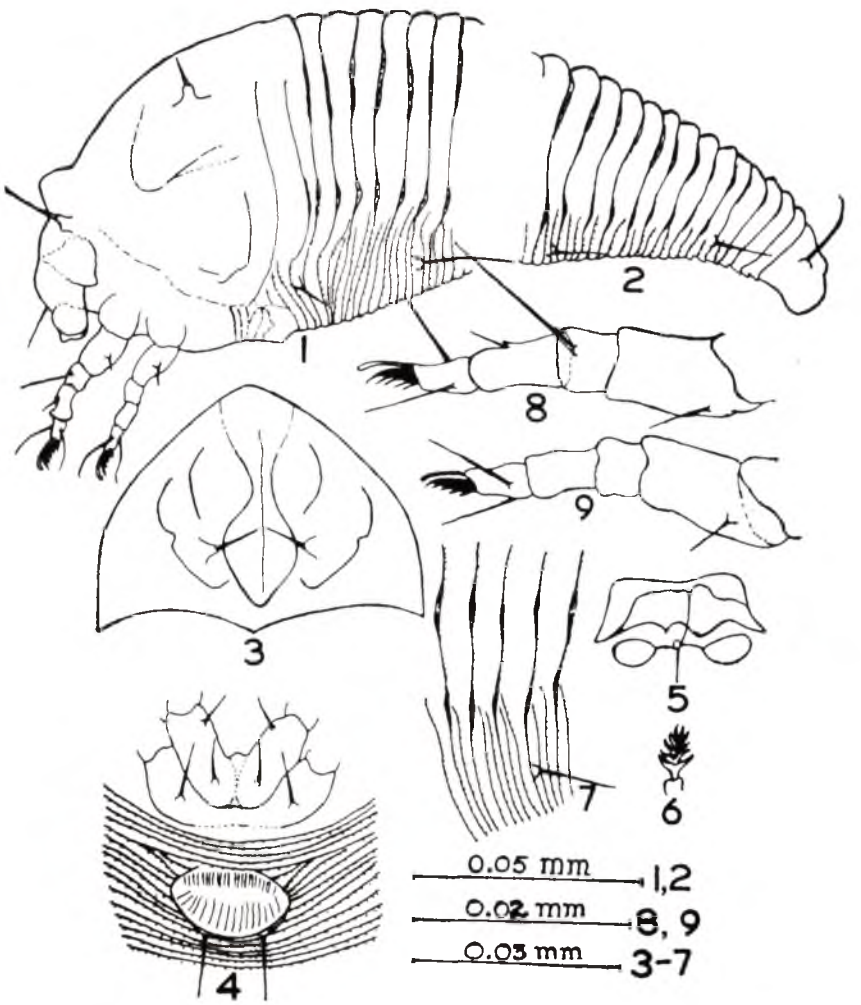
Two new species viz. *Calepitrimerus cordiae* sp. nov. (Eriophyidae) infesting *Cordia myxa* L. and *Calepitrimerus antedesmae* sp. nov. (Eriophyidae) infesting *Antedesma ghesembilla* Gaertn are described from West Bengal and Bihar, India. Relationship of these two species with the other known species of the genus, and host-mite relationship have also been discussed.

(Key words: Acarina, eriophyids, taxonomy, morphology, new species, India)

1. Calepitrimerus cordiae sp. nov. (Figs. 1—9).

Female: Body [1]168—175 long, 63—73 wide; robust, elongate, dark brick-red in colour with three deep wax ridges. Rostrum 15—20 long; moderately large, perpendicularly directed with body axis; subapical seta 2 long: shield 52—53 long, 52—65 wide, smooth, subtriangular, more or less blunt anteriorly, without distinct anterior lobe. Shield design simple; median line not continuous, lacking on anterior 0.25 portion and posterior 0.20 portion; admedian lines sinnate arising directly from shield margin and converge up to 0.5 part of the shield and then diverge up to 0.73 part and finally converge and meet with each other just behind the median line; submedian lines two; first submedian line short, sinnate and divergent outwardly, arises just behind; lateral margin and ends near the dorsal tubercles; second submedian line arises behind the lateral margin, progressively curved towards the admedian lines with a deep notch at the middle portion; dorsal tubercles 21 apart and ahead of rear margin; dorsal seta 6 long and directed up and centrad. Foreleg 30—35 long from trochanter base, femur 10.56 long with seta 5.76 long, patella 4.80 long with seta 19.20 long, tibia 7.86 long with seta 4.80 long, tarsus 5.76 long; with two tarsal setae 11—16 long each; claw without knob, 5.76 long; featherclaw 5-rayed, simple. Hindleg 25—33 long from trochanter base, femur 8—12 long with seta 8.64 long, patella 3.84 long, patellar seta absent, tibia 6.72 long without tibial seta, tarsus 4.80 long with two tarsal setae 12.48 long each. Claw and featherclaw like foreleg. Coxae with some curved lines, first coxae connate centrally without any distinct sternal line; first coxal seta well above the level of coxal approximation. First coxal seta 4.5 long, second coxal seta 4—8 long, third coxal seta 16.5 long. Abdomen more or less tapering and gradually conical at

[1]Measurements of size are in μm unless otherwise stated.



Figs. 1—9. *Calepitrimerus cordiae* sp. nov., Female: 1. lateral anterior view of the mite; 2. caudal view of mite, 3. anterior dorsum of mite; 4. coxae and female genitalia; 5. internal female genitalia; 6. featherclaw (Empodium); 7. side view of skin structure; 8. foreleg; 9. hindleg.

the caudal end, thanosoma with 25—28 tergites and 60—67 sternites, tergite with a central ridge fading caudad and almost absent in last at least 5—6 tergites; a subdorsal ridge is also present which is shorter than the middorsal one; microtubercles present on both tergites and sternites; lateral seta 12—15 long on about 7—8 sternites, first ventral seta 20—27 long on about 20—23 sternites, second ventral seta 12.48 long on about 39—43 sternites, third ventral seta 15.36 long on about 53—60 sternites; accessory seta absent; caudal seta 14.80 long. Female genitalia 4—5 ring behind coxae, 15 long, 24 wide, genital flap with scoring in two tiers, upper one

contains 16—24 and lower one contains 14—16 in number, genital seta 6 long.

Male: Unknown.

Holotype: ♀ (on slide No. 133/76/80) INDIA: WEST BENGAL: BIRBHUM: Sriniketan, 6. vii. 80 from *Cordia myxa* L. (Boraginaceae) (coll. A. K. Das).

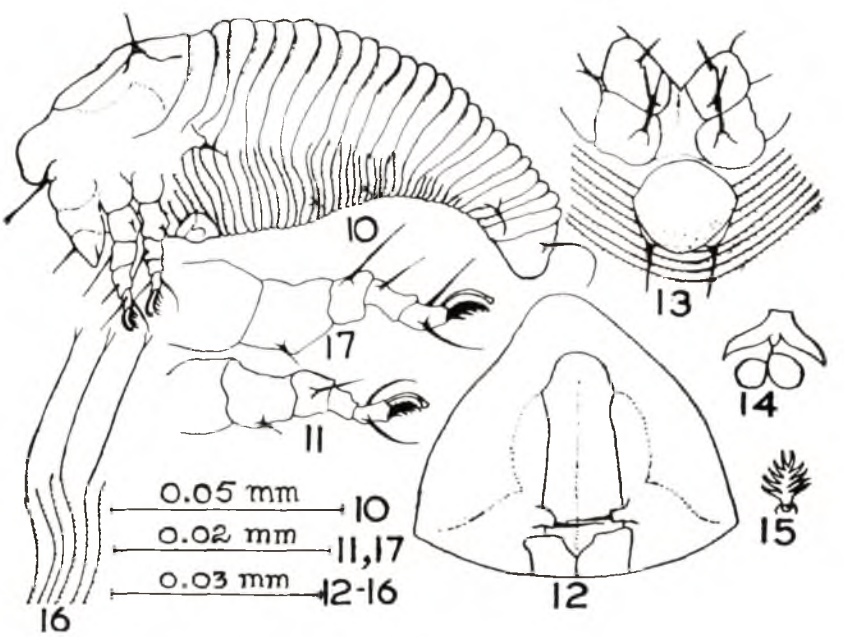
Paratype: Many ♀♀ (on slides Nos. 134/76/80 to 138/76/80). collection data as in the holotype.

Distribution: India: West Bengal.

The mites are vagrant on ventral surface of leaves. Due to infestation of these mites brown patches are noticed on the undersurface of the leaves particularly at the peak of population (June—July).

2. Calepitrimerus antedesmae sp. nov. (Figs. 10—17).

Female: Body 96—105 long, 40—49 wide; thick, robust, markedly narrowed from about last 11—12 rings posteriorly pale darkish white in colour. Rostrum 15.75 long, moderately large, dagger-shaped; subapical seta 7 long. Shield 36—41 long, 43—46 wide, smooth; subtriangular, with distinct anterior lobe; median line faint, not continuous, absent on anterior 0.33 part and posterior 14 part; admedian lines jointed anteriorly just anterior to the median line and bifurcate just below the dorsal tubercles; the inner branches run convergently and meet on the median ine just anterior to the near margin; the louter branch is faint and run divergently and meet the near margin: submedian single, arises from a notch on admedian lines at 0.31 part of shield and form an arch outwardly upto 0.66 part where a second notch is formed and again it runs laterally; dorsal tubercles centrad, 15.5 apart, well ahead of near shield margin setae 7.5 long. Foreleg 24 long from



Figs. 10—17. *Calepitrimerus antedesmae* sp. nov., female: 10. lateral view of mite; 11. hindleg; 12. anterior dorsum of mite; 13. coxae and female genitalia; 14. internal genitalia; 15. featherclaw (Empodium); 16. side view of skin structure; 17. foreleg.

trochanter base; femur 5.76 long with seta 4.80 long, patella 4.80 long with seta 7.86 long, tibia 4.80 long with seta 5.76 long, tarsus 4.80 long with two setae 8.64 long each; claw 4.80 long, moderately knobbed, featherclaw 5-rayed. Hind leg 22 long from trochanter base, femur 5.76 long with seta 3.84 long, patella 3.84 long, with seta 7.68 long, tibia 4.80 long, seta absent, tarsus 3.84 long with two setae 8.64 long each; claw and featherclaw as in foreleg. Coxae smooth, anterior coxae connate apically, sternal line faint, first coxal setae 6 long well ahead of anterior coxal approximation, second setiferous coxal setae 6 long, third coxal setae 12 long. Abdomen more or less tapering, conical at caudal end, thanosoma with 24—28 tergites and 42—49 sternites, last 5—6 tergites not differentiated from sternites; mid-dorsal ridge absent on last 7—8 tergites giving a trough, subdorsal ridge present upto last 5—6 tergites; sternites with very fine microtubercles; lateral setae 5.25 long on about 3—4 sternites; first ventral setae 3.5 long on about 16 sternites; second ventral setae 1.70 long, on about 23—24 sternites, third ventral setae 8 long on about 42—48 sternites; accessory seta absent; caudal seta 12.25 long. Female genitalia 13.50 long, 15 wide, smooth, some fine granules present on lower margin, seta 6 long.

Male: Unknown.

Holotype: ♀ (on slide No. 139/77/80), INDIA : WEST BENGAL : NADIA : Kalyani, 9. v. 79 from *Antedesma ghesembilla* Gaertn (Euphorbiaceae) (coll. S. Mondal).

Paratype: Many ♀♀ (on 5 slides Nos. 140/78/80 to 144/78/80) INDIA:BIHAR: SANTHAL PARGANA : Massanjore, 1. ix. 80 from *Antedesma ghesembilla* Gaertn (coll. A. K. Das).

Distribution: India:Bihar:West Bengal.

The mites are vagrant on ventral surface of leaves and tender apical stems. No significant damage symptom was noticed.

Remark: So far 4 species viz. *Calepitrimerus sibbaldiae* Roivainen (1950), *C. asiminae* Styer (1975), *C. fragisylvaticus* Keifer. (1965), *C. mysorensis* Channabasavanna (1966) and 2 new species *C. cordiae*, *C. antedesmae* are known with 5-rayed featherclaw. *C. cordiae* sp. nov. and *C. antedesmae* sp. nov. can be differentiated from the above 4 known species by its shield design and fewer number of tergites. However, with regard to fewer number of tergites and sternites *C. cordiae* and *C. antedesmae* also show their affinity with *C. gilsoni* Keifer (1953), *C. darrowi* Keifer (1940), and *C. azadirachtae* Channabasavanna (1966), but in these species the featherclaw and shield design are different. *C. cordiae* differs from *C. antedesmae* in having distinct and longer first and second ventral setae. Beside these *C. cordiae* differs from *C. antedesmae* in shield design and prominent longitudinal scoring on genital coverflap.

All the type slides are deposited in the collection of the Entomology Laboratory, Department of Zoology, University of Kalyani.

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ONE NEW SUBGENUS, THREE NEW SPECIES AND ONE NEW SUBSPECIES OF APHIDS (HOMOPTERA) FROM SIKKIM, NORTH EAST INDIA

BASANT K. AGARWALA, P. K. MONDAL & D. N. RAYCHAUDHURI

Entomology Laboratory, Department of Zoology,
Calcutta University, Calcutta, India 700 019

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This paper includes one subgenus, three species and one subspecies of aphids described as new to science from Sikkim

(Key words : Aphids, new to science from Sikkim).

Exploration of Sikkim state has revealed the occurrence of one new subgenus, three new species and one new subspecies of aphids viz. *Impatientinum (Neoimpatientinum) smilaceti*, subgen. *et* sp. nov. and *Metopolophium (Microlophium) darjeelingense lacheni*, sp. nov. belonging to the subfamily Aphidinae; *Mollitrichosiphum nigriabdominalis*,sp. nov. belonging to the subfamily Greenideinae and *Paraoregma orientalis*, sp. nov. belonging to the subfamily Hormaphidinae.

Material of the reported aphids are in the collection of Aphid Research Unit, Entomology Laboratory, Department of Zoology, Calcutta University.

Impatientinum (Neoimpatientinum) smilaceti, subgen. *et* sp. nov.

Apterous viviparous female: Fig. 1: Body elongated, oval, about 2.82—2.95 mm long with 1.01—1.36 mm as its maximum width. Head smooth, with hardly developed median frontal prominence and a pair of diverging lateral frontal tubercles; dorsal cephalic hairs with acute to acuminate apices. Eyes multifaceted, with distinct ocular tubercles. Antennae 6-segmented, about 1.11—1.15 × body, pale with apices of segments III, IV and V and whole of segment VI dark brown; basal portion of segment III smooth, res of flagellum gradually more distinctly imbricated apicad; p. t. about 1.05—1.09 × segment III and about 4.35—4.94× base of segment VI; segment III with 2 oval secondary rhinaria at base; hairs on flagellum short with acuminate apices, longest hair on segment III about 0.63 × basal diameter of the segment. Rostrum extends up to midcoxae; u. r. s. blunt, about 0.67—0.68 × h. t. 2, bearing 4 secondary hairs. Midthoracic furca with a short base. Abdominal dorsum smooth with an 'U' shaped marginal dark patch and a pale median area extending upto segment 7; dorsal hairs short with blunt to acuminate apices, longest hair on anterior abdominal tergites about 1.36—1.45 × b. d. III, tergite 7 and 8 with long, acute to acuminate hairs and longest one on these segments about 1.36—1.45 × and 1.36—1.63 × b. d. III respectively. Siphunculi calf-shaped, dark brown, basally smooth but distally more distinct imbricated and with some transversely drawn

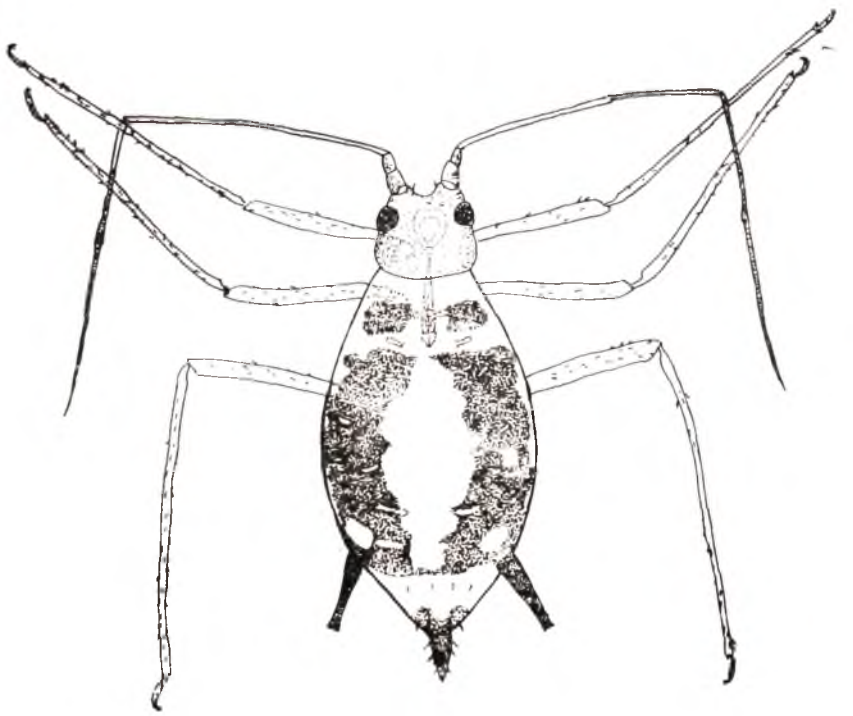


Fig. 1. *Impatientinum* (*Neoimpatientinum*) *smilaceti*, subgen. *et* sp. nov. Apterous viviparous female.

out cells near apex, with a hardly developed flange, about 0.18—0.19 × body and about 1.33 — 1.48 × pale, tongue shaped cauda bearing 6 long fine hairs. Legs slender and pale with spinules on femora; tarsi normal; first tarsal chaetotaxy 4,4,4.

Measurement of the holotype in mm: Length of body 2.95, width 1.36; antenna 3.28, segments III: IV: V: VI 0.79: 0.56: 0.52: (0.17+0.83); u. r. s. 0.11; h. t. 2,0.17; siphunculus 0.55; cauda 0.35.

Material examined: **Holotype**: Apterous viviparous ♀ INDIA: SIKKIM: Lachung (*c* 3000 m), 6. iv. 1975 from *Salix macrophylla* (Liliaceae); **paratypes**: 2 apterous viviparous ♀♀ and 6 nymphs, collection data as in the holotype.

Remarks: The genus *Impatientinum*, according to Hille Ris Lambers (1947) and Miyazaki (1971), is known to possess first tarsal chaetotaxy 3,3,3 and a consolidated dark patch with margins on abdomen pale. However, a few aphid specimens collected in Sikkim though agreeing with the concept of this genus possess first tarsal chaetotaxy 4,4,4 and abdominal dorsum pale on spinopleural regions but margins darker. Under the circumstances, a new subgenus *Neoimpatientinum* under *Impatientinum* is erected to accomodate those specimens described here as new.

According to Miyazaki (1971), species of the genus alternate between *Smilax* and *Impatiens*. In India 3 species and 1 subspecies are now known under the genus of which *I. asiaticum dalhousiensis* Verma and *I. impatiens* (Shinji) only alternate between *Smilax* spp. and *Impatiens* spp.

Metopolophium (Microlophium) darjeelingense lacheni, ssp. nov.

Raychaudhuri, Ghosh and Basu (1975) described *Metopolophium (Microlophium) darjeelingense* from apterous viviparous female only. The new subspecies is represented by apterous and alate viviparous females, apterous oviparae and alate male.

Apterous viviparae (Fig. 2A-C) of new subspecies differs from apterous viviparous

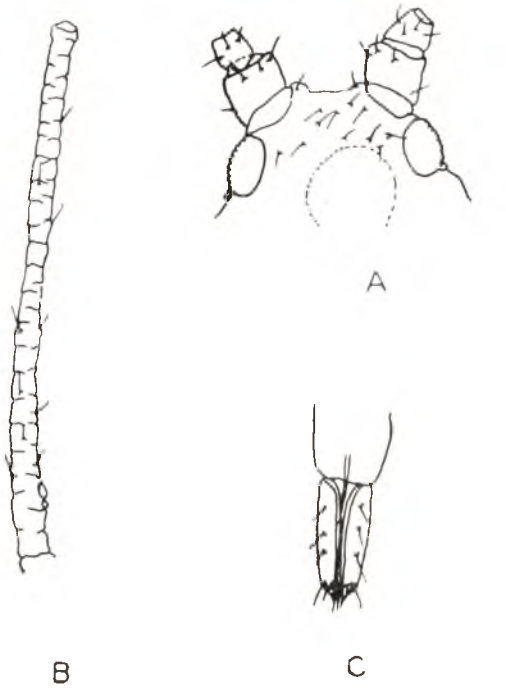


Fig. 2. *Metopolophium (Microlophium) darjeelingense lacheni*, ssp. nov. Apterous viviparous female : A. dorsum of head; B. antennal segment III; C. Ultimate rostral segment.

female of nominate subspecies in the following:

i) longest hair on antennal segment III, 0.53—0.57 × b. d. III (vs. 0.77—1.44 × b. d. III) in *darjeelingense*)

ii) longest hair on 7th tergite about 0.80—1.07 × b. d. III (vs. 1.50—1.72 × b. d. III).

iii) siphunculi 2.60 — 3.20 × cauda and 0.28—0.31 × body (vs. 2.0 × cauda and 0.20—0.21 × body).

iv) siphunculi sparsely imbricated (vs. distinctly imbricated).

v) femora apically sparsely imbricated (vs. throughout smooth).

These differences justify the erection of a new subspecies. Alate viviparous female: Fig. 3: Body about 2.85 mm long with about 1.15 mm as maximum width. Head (Fig. 3A) brown, smooth; lateral frontal tubercles well developed, diverging and with scabrous inner margins; median frontal prominence low; dorsal cephalic hairs long with blunt to incrassate apices median ocelli prominent. Antennae 6-segmented, about 0.78 × body; segment III (Fig. 3B) with 23—29 round somewhat protuberant secondary rhinaria arranged in a row along outer margin except basal and apical 1/3rd portion which sparsely imbricated, rest portion of the segment and the flagellum distinctly imbricated; flagellar hairs with incrassate apices, longest one on segment III about 1.62 × b. d. III; p. t. about 5.60 × base of segment III, primary rhinaria ciliated. Ultimate rostral segment (Fig. 3C) stout as long as h. t. 2 and bears 6 secondary hairs. Ante-siphuncular tergites (2—4) with spinal and pleural sclerites besides marginal ones on either sides, the spinals and pleurala fusing together forming transverse bands; dorsal hairs long with incrassate apices, each of tergites 7 and 8 with 4 hairs, the longest one on anterior tergites about 1.0—1.21 × b. d. III, those on tergites 7 and 8 about 1.36 and 1.63 × b. d. III respectively. Siphunculi cylindrical, about 0.20 × body, sparsely imbricated except basal 1/3 rd which is almost smooth. Cauda broad basally and narrow apically brown, with distal portion of tibiae and whole of tarsi dark brown; femora smooth,

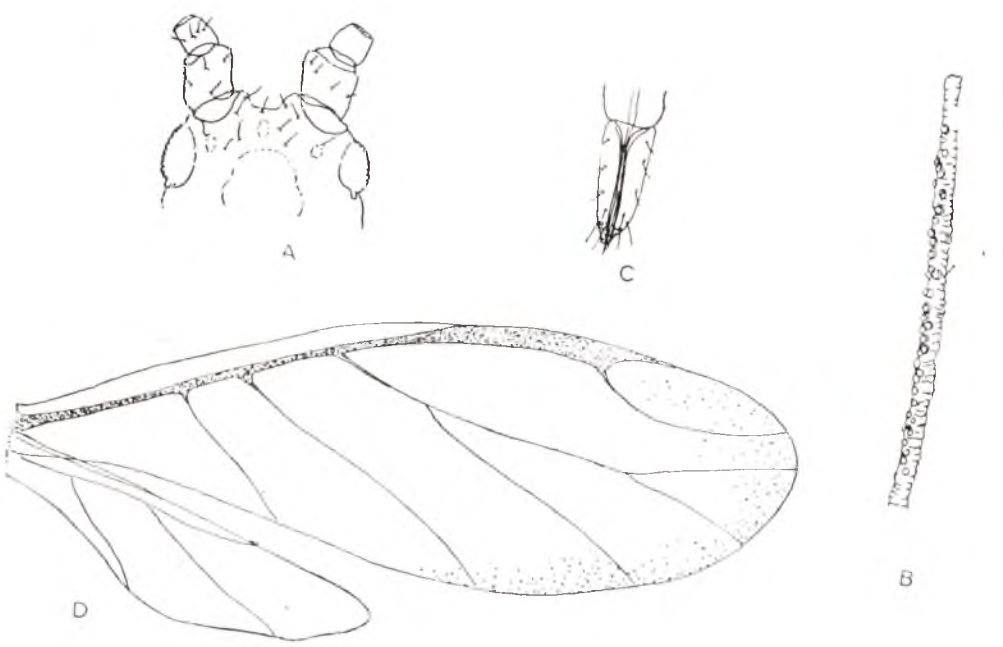


Fig. 3. *Metopolophium (Microlophium) darjeelingense lacheni*, ssp. nov. Alate viviparous female : A. dorsum of head; B. antennal segment; C. Ultimate rostral segment; D. fore and hind wings.

tibiae imbricated; hairs on legs with incrassate apices except those on distal portion of tibiae having subacute apices; first tarsal chaetotaxy 3,3,? Wing venation (Fig. 3D) normal; veins thick and brown.

Measurement of the alata in mm: Length of body 2.85, width 1.15; antenna 3.82, segments III: IV: V: VI: 1.08: 0.79: 0.60: (0.21 + 1.05); u. r. s. 0.18; h. t. 2 0.18; siphunculus 0.58; cauda 0.22.

Apterous oviparous female: Fig. 4: Body pale, about 1.70—2.36 mm long with maximum width as 0.77—1.25 mm. Head brown. Antennae 6-segmented, about 0.72—0.89 × body; segments I, II and basal half of III (Fig. 4A) concolorous with head and rest gradually becoming dark; p. t. about 4.25—5.45 × base of segment VI. Ultimate rostral segment (Fig. 4B) blunt, as long as h. t. 2. Siphunculi rather stout, cylindrical with a broad base, about 0.22—0.27 × body. Cauda bearing 7—11 hairs. Hindtibiae (Fig. 4C) swollen, more so on basal half, bearing numerous pseudosensoria throughout excepting at apical 1/3rd and basal 1/4th portion. Otherwise as in apterous viviparous female.

Measurement of one specimen in mm: Length of body 1.71, width 0.88; antenna 2.36; segments III: IV: V: VI: 0.54: 0.40: 0.35: (0.16 + 0.71); u. r. s. 0.14; h. t. 2 0.15; siphunculus 0.47; cauda 0.75.

Alate male: Fig 5: Body 2.79 mm long with 1.25 mm as the maximum width. Head brown. Antennae 6-segmented brown, 1.47 × body; segment III (Fig. 5A) with 54—56, segment IV with 3 and segment V with 14 secondary rhinaria distributed irregularly over their entire length; p. t. about 5.81 × base of last antennal segment. Rostrum brown; u. r. s. (Fig.

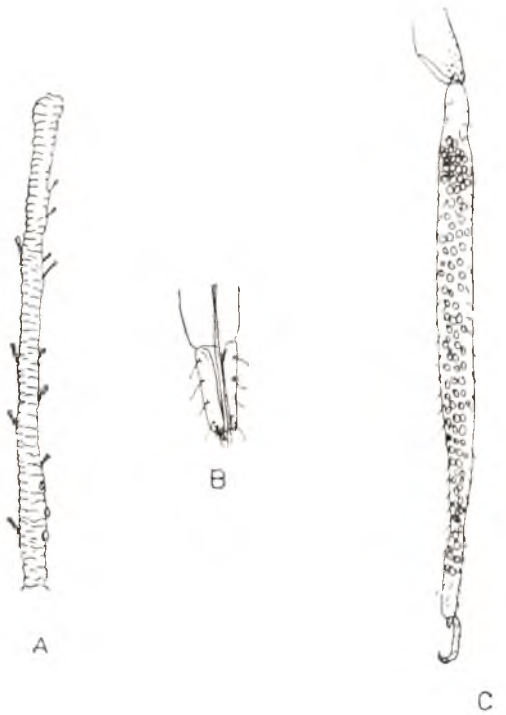


Fig. 4. *Metopolophium (Microlophium) darjeelingense lacheni*, ssp. nov. Apterous oviparous female: A. antennal segment III; B. ultimate rostral segment; C. hind-tibia showing pseudosensoria.

5 B) blunt, as long as h. t. 2. Dorsum of abdomen pale with brownish spinopleural patches besides marginal ones on segments 2—5. Siphunculi light brown, nearly cylindrical with basal and apical parts broadened, slightly imbricated, about 0.20 × body and 2.56 × digitiform, dark cauda. Male genital organs well developed. Legs dark. Wing venation normal; veins pale brown and thick. Otherwise as in alata vivipara.

Measurement of the alate male in mm: Length of body 2.79, width 1.25; antenna 4.12, segments III: IV: V: VI: 0.91; 0.87: 0.62: (0.22+1.29); u. r. s. 0.17; h. t. 2 0.17; siphunculus 0.57; cauda 0.22.

Material examined: **Holotype**: Apterous viviparous female, INDIA, SIKKIM: Lachen (*c* 3000m), 7. xii. 1975 from *Pubus* sp. (Rosaceae); **Paratype:** 1 apterous viviparous female, 4 apterous oviparous females and 1 alate male collection data same as in the holotype.

Mollitrichosiphum nigriabdominalis, sp. nov.

Apterous viviparous female: Fig. 8: Body elongated, about 2.20—2.29 mm long with about 0.87—1.04 mm as maximum width. Head smooth, flat, without any lateral frontal tubercles. Antennae 6-segmented, about 0.75—0.78 × body, pale upto base of 5th segment and rest darker; prominently imbricated; flagellum with many long hairs having pointed apices and these pointed on all sides; p. t. about 0.42—0.47 × segment III and about 1.50—1.69 × base of antennal segment VI. Rostrum elongated, extending beyond hindcoxae; rostral segments 4+5 about 1.74—

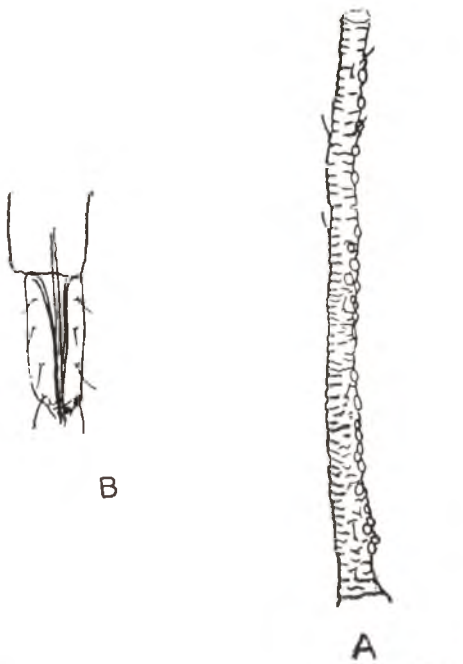


Fig. 5. *Metopolophium (Microlophium) darjeelingense lacheni*; ssp. nov. Alate A. antennal segment III; B. ultimate rostral segment.

2.05 × h. t. 2; segment 4 about 5.25—6.40 × segment 5 and segment 4 bears 14 secondary hairs. Abdominal tergum sclerotised smooth with a central median dark patch. Siphunculi pale, cylindrical, with a spinules near the apical region besides long fine hairs which are distributed over entire length, about 0.51—0.57 × body and about 7.06—8.36 × its basal diameter. Cauda rounded, bearing 6 hairs. Femora coloured like body, tibiae pale brown with nearly 14 transverse cuts restricted on basal half; first tarsal chaetotaxy 7,7,7.

Measurement of the holotype in mm: Length of body 2.16, width 1.04; antenna 1.66, segments III: IV: V: VI 0.58: 0.20: 0.23: (0.16+0.27); u. r. s. (4+5) 0.25; h. t. 2,0.12; siphunculus 1.13.

Meterial examined: **Holotype:** Apterous viviparous female, INDIA: SIKKIM, Sanklang (*c* 1000 m), 3. xi, 1974 from *Quercus rubra* (Fagaceae); **Paratypes:** 12 apterae and 4 nymphs, collection data same as in holotype.

Biological note: Insects with dark abdominal patch infest mainly the stem and were found in big colonies, not attended by ants.

Remark: This new species comes close to *Mollitrichosiphum shinjii* Raychaudhuri *et al.* but differs from it in the following key characters:

Abdominal tergum with a distinct median brown patch; siphunculi 0.50—0.57 × body.....*nigriabdominalis* sp. nov.

Abdominal tergum pale; siphunculi 0.72—0.80 × body.....*shinjii* Raychaudhuri, Ghosh, Banerjee and Ghosh

Paraoregma orientalis, sp. nov.

Apterous viviparous female: Fig. 6 : Body paler shaped, about 2.22—2.5mm long and 1.33—1.65 mm as maximum width. Head (Fig. 6A) and pronotum fused, brown with anterior margin darker; dorsum with

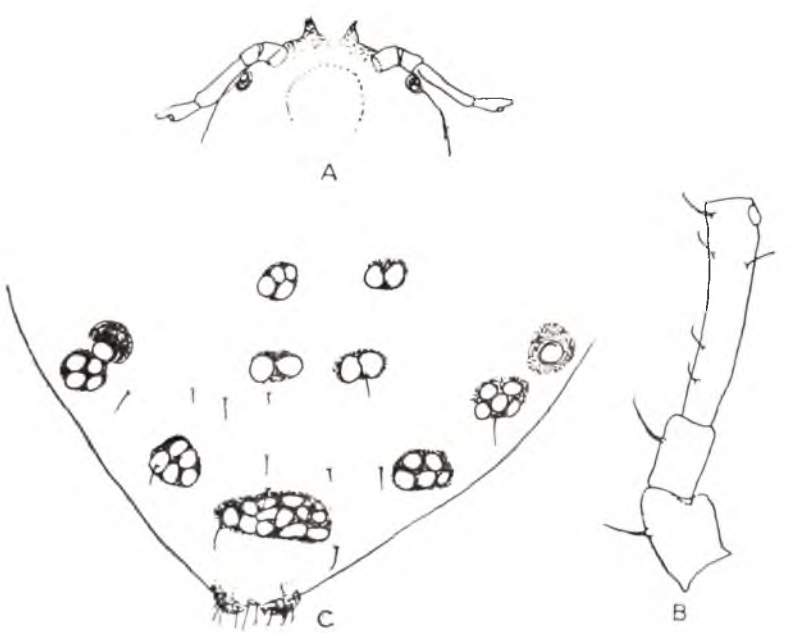
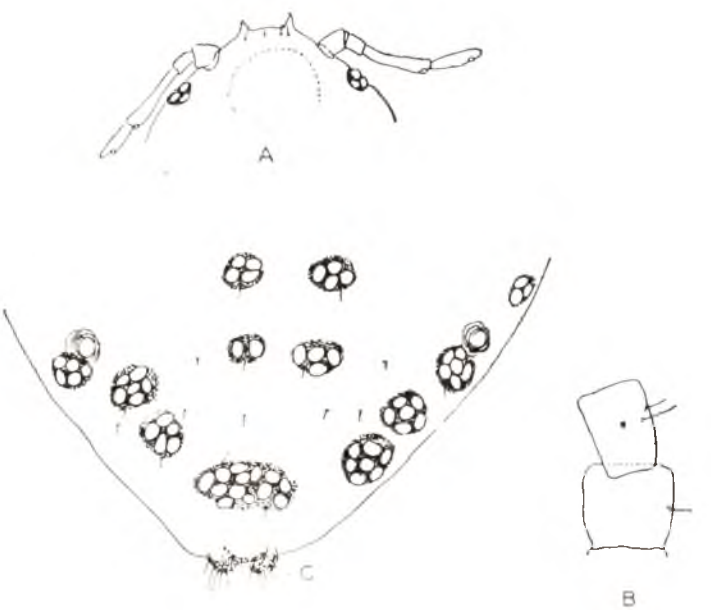


Fig. 6. *Paraoregma orientalis*, sp. nov. Apterous viviparous female : A. head; B. antennal segment I-III; C. posterior portion of abdomen.

numerous round to oval wax pores: dorsal hair long with blunt to acuminate apices, longest one about 0.58—0.85 × length of antennal segment II and bears 3—5 short hairs. Antennae (Fig. 6B) 4-segmented, 0.14—0.20×length of body; segments I and II smooth and bears 1 and 2 hairs respectively, segment III and IV imbricated, bearing 3—6 and 2—3 hairs respectively besides hairs on p.t., longest hair on segment III 0.62—1.0×basal diameter of the segment; p.t. 2.75—3.33×base of segment IV; flagellar hairs with blunt or fine apices; circular primary rhinaria on IVth segment ciliated; Rostrum extends between first and second coxae; u.r.s. short and blunt, about 0.52—0.62×h.t. 2, without any secondary hair. Marginal sclerotic areas studded with wax pores present on each side of meso- and metathoracic tergites. Dorsum of abdomen (Fig. 6C) pale; tergites 1—3 with pigmented areas bearing wax pores on margins, one pair of spino-pleural sclerites with wax-gland cells on tergites 1—7 and on tergites 4—6, such sclerites also placed marginally; tergite 8 with a spino-pleural transverse band bearing 11-13 wax-gland cells placed in two to three rows, wax-gland cells on marginal sclerites never exceeds 8 and those on spino-pleural region do not exceed 5: each marginal sclerite with one long and fine hair, similar hairs also present on dorsum of abdomen, tergite 8 with 4 such hairs, longest hair on anterior tergites about 0.50×b.d. III and those on 8th tergite 2.50—3.33×the mentioned diameter. Siphunculi poriform, placed on brown elevated but low cones and not surrounded by hairs. Cauda somewhat transversely oval, bearing 7—9 long and fine hairs. Subanal plate distinctly bilobed. Legs pale brown; femora and tibiae smooth; tarsi imbricated; first tarsal chaetotaxy 4, 4, 2; one of the dorso-apical hairs with funnel-shaped apices and the other one with finely drawnout apices.



Fi g. 7. *Paraoregma orientalis*, sp. nov. Alate viviparous female: A. head; B. segment I and II; C. posterior portion of abdomen.

Measurement of the holotype: Length of body 2.50, width. 1.46; antenna 0.36, segments III : IV 0.14 : (0.07+0.012; u. r. s. 0.077; h. t. 2 0.15; siphuncular pore 0.05.

Alate viviparous female: Fig. 7: Body 2.37-2.43 mm long and 1.0—1.12mm as the maximum width. Head (Fig. 7A) dark brown on anterior half, brown on posterior half; dorsal cephalic hairs short, stout, sparse and with acute apices. Antennae 5-semented, about 0.36—0.42×length of body; segments I and II (Fig. 7B) spinulose, bearing 2 and 4 hairs respectively, concolorous with head; flagellum dark bearing annular secondary rhinaria throughout, with spinular imbrications, segment III with 2, segment IV with 5 and segment V with 1 short hairs on basal part; p. t. short, about 0.06—0.07×base of segment V; primary rhinaria round and ciliated. Rostrum extends a little beyond midcoxae; u. r. s. rather blunt, without any secondary hair and 0.58—0.62×h.t.2. Abdomen pale (Fig. 7C), tergites 7 and 8 with transverse pigmented bands; dorsal hairs short to long with fine apices; longest hair on anterior tergites about 1.80×b. d. III and that on tergite 8 about 2.60—3.25×the mentioned diameter; tergite 8 bearing 3—4 hairs. Siphunculi poriform, surrounded by a sclerotic rim. Cauda semicircular, bears 17—20 hairs. Legs dark brown; first tarsal chaetotaxy 4, 4, 2; dorso-apical hair as in apterae. Media of forewing once-branched; pterostigma extending over entire length of radial-sector; veins bordered brown.

Fig. 8. *Mollitrichisiphum nigriabdominalis*, sp. nov. Apterous viviparous female.

Measurement of one alata in mm: Length of body 2.43, width 1. 11; antenna 1.03, segments III:IV:V 0.43; 0.23; (0.21+0.01): u. r. s. 0.08; h. t. 2 0.14; siphuncular pore 0.04.

Remarks: The new species can be differentiated from only other species *alexanderi* known under the genus in the following key characters:

Apterous viviparous female:

Frontal horns 0.58—0.85 × length of 2nd antennal segment, bears 3—4 hairs; dorsal cephalic hairs 1.62—2.12 × b. d. III; 3rd antennal segment with 3—6 hairs.....*orientalis*, sp. nov.

Frontal horns 1.30—1.70 × length of 2nd antennal segment, bears 6—8 hairs; dorsal cephalic hairs 1.16—1.20 × b. d. III; 3rd antennal segment with 6—7 hairs.....*alexanderi* (Takahashi)

Alate viviparous female:

Antennal segment I, II and III with 3, 3 and 2 hairs respectively; 8th tergite with 3—4 hairs; cauda bears 16—20 hairs.....*orientalis*, sp. nov.

Antennal segments I, II and III with 2, 4 and 3—4 hairs respectively; 8th tergite with6 hairs; cauda bears 10-12 hairs.....*alexanderi* (Takahashi)

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BRIEF COMMUNICATION

MASS REARING TECHNIQUE FOR AN INDIGENOUS PREDATORY MITE, *AMBLYSEIUS (TYPHLORDOMIPS) TETRANYCHIVORUS* (GUPTA) (ACARINA : PHYTOSEIIDAE) IN THE LABORATORY

A. KRISHNAMOORTHY

National Centre for Biological Control, Indian Institute of Horticultural Research, Bangalore - 32

(Received 13 December 1980)

The indigenous predatory mite, *Amblyseius (Typhlodromips) tetranychivorus* (Gupta) is confined on a suitably prepared glass substrate which has obviated the need for using host plant material. Castor pollen is used as food material for the predatory mites instead of host spider mites.

(Key words: Amblyseius (Typhlodromips) tetranychivorus, phytoseiid mite)

The introduction of new cultural practices to increase yields and the extensive use of chemical pesticides for the control of insect pests has resulted in severe spidermite out-breaks on various crops (WEI-LAN MA & LAING, 1973). Pesticides have been largely responsible for the disappearance of natural enemies of spidermites. Indiscriminate use of pesticides has also led to the development of resistant populations. PUTMAN & HERNE (1958), CHANT (1963) and HUFFAKER & FLAHERTY (1966) have clearly illustrated that spidermites are kept under relatively good control by their natural enemies in untreated areas. Of the natural enemies of spidermites, predatory mites of the family Phytoseiidae are of economic interest because many species prey exclusively on phytophagous mites (MCMURTRY & SCRIVEN, 1965). In view of their importance, attempts were made to mass-breed predatory mites in the laboratory for field application against spidermites on vegetable crops such as okra, brinjal and beans which are often cultivated by marginal farmers in India. Methods of rearing predatory mites on plant material have several disadvantages since they are labour intensive, require more space, necessitate changing of leaves frequently and still provide low yields of predators. These difficulties were overcome substantially by using a technique described in this paper, based on that developed by MCMURTRY & SCRIVEN (1965).

The basic rearing substrate or unit for rearing *Amblyseius (Typhlodromips) tetranychivorus* (GUPTA) consists of an aluminium pan 20×20 × 4 cm and a wooden platform 10 × 7 × 2 cm, a glass plate 14× 12 × 0.20 cm covered with black paint on one side and wet cotton strips to prevent mites from escaping.

The wooden platform is kept in the centre of the aluminium pan. The glass plate is kept over the platform in such

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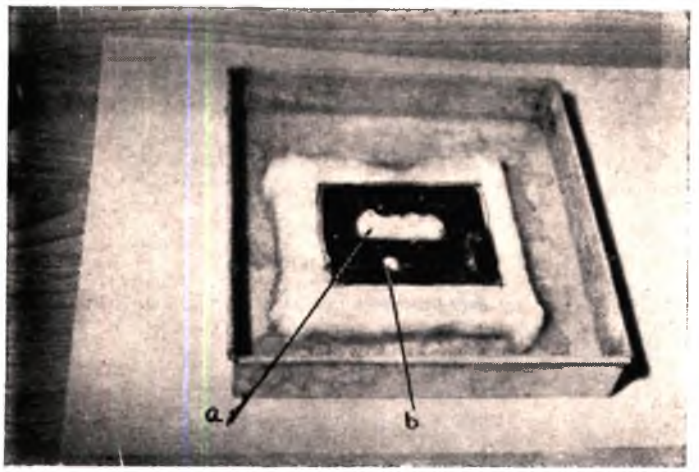

Fig. 1. Predatory mite rearing unit. a. cotton-wool strip provided for egg-laying; b. castor pollen.

a way that the painted surface faces down to form a good background for observation. A strip of wet cotton is kept all around the glass plate to prevent the predatory mites from escaping (Fig. 1). Sufficient water is maintained in the pan to keep the cotton strip saturated and maintain high relative humidity (85—88%) near the surface of the glass plate, because maintaining optimum humidity is extremely important for successful rearing of the mites (MCMURTRY & SCRIVEN, 1965). Cotton strands are stuck on the glass plate as sites for oviposition and resting.

To mass rear *A. tetranychivorus* in the laboratory, pollen grains from different crops were tested. MCMURTRY & JOHNSON (1965) have found that the unusually high levels of *A. hibisci* (CHANT) were apparently due to large quantities of pollen drifting from adjacent plants of *Ricinus communis* L. Based on these author's observations, castor pollen grains were used to rear *A. tetranychivorus*, which readily accepted the pollen grains, fed voraciously and laid eggs on the cotton-wool strands provided (Fig. 2). Pollen grains were removed from castor inflorescence by gentle tapping during the early hours of the day. The pollen grains could also be artificially removed by keeping the flowers in petri-dishes under a 60 W electric lamp for about 5 minutes. The pollen grains were then brushed off from the petridishes for feeding or storage. Pollen grains could be stored at 3—4°C in a refrigerator for at least 2 weeks, or in a deep freeze for several months. However, the pollen grains which had been frozen did not appear to be as favourable for food as fresh pollen grains (MCMURTRY & SCRIVEN, 1965).

The rearing units were kept in racks in a partially darkened chamber. The cultures were maintained at room temperature of 30° ± 2°C and RH of 45—50%. Individual tray cultures remained in satisfactory condition for more than 10 weeks. Strands of cotton-wool were changed often to get better egg production. Pollen grains were provided once in two days and approximately 4 mg were required for about

Fig. 2. Cotton-wool strands bearing eggs of *A. tetranychivorus*

500 adult mites. The culture tray units were convenient to handle and the developing predacious mites could be closely examined with a binocular microscope.

To begin a new unit, 200 to 250 fresh adults were collected from the old tray using a fine camel hair brush. After 2—3 weeks the populations usually increased sufficiently to provide sufficient material for field liberations.

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BRIEF COMMUNICATION

HEAVY LEAF DAMAGE OF GREENGRAM AND BLACKGRAM BY GALERUCID BEETLE, *MADURASIA OBSCURELLA* JACOBY (COLEOPTERA:CHRYSOMELIDAE) AT VARANASI (U. P.)

JANARDAN SINGH & P. K. GUPTA

Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi - 221 005

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The damage to the leave of greengram and blackgram by adults and the nodule damage by the grubs of *Madurasia obscurella* Jacoby is reported at Varanasi. It was observed that 35 to 65 per eent leaves were having holes and average numbers per leaf were 4 to 7. The grubs of this beetle were seen in the soil damaging the nodules of the plants.

(Key words: Madurasia obscurella Jecoby, greengram and blackgram, heavy leaf damage)

A study of insect pests of two 'Kharif' pulses viz., greengram *(Vigna radiata* L.) and blackgram *(Vigna mungo* L.) was made in the years 1978 and 1979. It was observed that chrysomelid beetles in large number were present in the fields. These beetles were collected and reared in the laboratory on the greengram and blackgram plants in the pots for the study of their feeding activity and type of damage to the plants by them.

Though the adult of *Madurasia obscurella* was described by MAULIK (1936) from Nilgiri but no host plant was recorded MENON & SAXENA (1970) first reported about this beetle from I. A. R. I., New Delhi, and stated that the adult beetles damaged the leaves of greengram, blackgram and redgram. SRIVASTAVA & SINGH (1976) described it as a pest of 'Kharif' pulses in Uttar Pradesh.

The damage to the plants was caused by adult galerucid beetles by feeding the leaves in large numbers, mainly during night and in the cooler parts of the day. The damaged leaves showed characteristic perforations or short holes (Fig. 1). This damage led to the reduction in grain yield due to retarded photosynthetic activity.

Three trifoliate leaves (upper, middle and lower) from each of the randomly selected 10 plants of greengram and blackgram fields were observed. Thus, total 30 leaves were observed for the assessment of damage caused by galerucid beetles. Number of leaves having holes and total number of holes in 30 trifoliate leaves were recorded at different sites in Varanasi region. Percentage of leaves damaged and average number of holes per leaf was calculated. The maximum percentage of leaves damaged and number of holes per trifoliate leaf for greengram was after 6 weeks of sowing at both the sites while for blackgram the maximum percentage of leaves damaged and number of holes per trifoliate was after 8 weeks of sowing (Table 1). Thus it seems that the infestation time differs between the two crops leading to the conclusion that infestation

TABLE 1. Percentage of damaged leaves and average number of holes per trifoliate leaf made by galerucid beetle (*Madurasia obscurella*) to greengram and blackgram.

Crop	Observation week	Agricultural Research Farm, Banars Hindu University, Varanasi		Regional Demonstration and Research Centre, Govt. of Uttar Paradesh, Lahartara Varanasi	
		Percentage of damaged leaves	Average number of holes/trifoliate leaf	Percentage of damaged leaves	Average number of holes/trifoliate leaf
	Date of sowing 5th July, 1978				
Green	4th W. A. S.	36.63	4.07	30.33	3.67
Gram	6th W. A. S.	53.33	5.50	46.67	5.23
(T-44)	8th W. A. S.	43.33	5.33	40.00	4.93
	10th W. A. S.	40.00	4.67	33.33	4.20
	Date of sowing 5th July, 1978				
Black	4th W. A. S.	40.00	5.40	46.67	5.67
Gram	6th W. A. S.	60.00	7.05	56.67	6.20
(T-9)	8th W. A. S.	66.67	6.83	66.67	6.80
	10th W. A. S.	53.33	6.33	53.33	7.17

W. A. S. = Weeks After Sowing.

was more pronounced in blackgram than greengram at both the sites. The grubs of this beetle were also seen in the soil near the roots of plants and they were found feeding on the root hairs and nodules of the host plants (Fig. 2).

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Fig. 1. Leaf damage by adult galerucid beetle (*Madurasia obscurella* Jacoby).

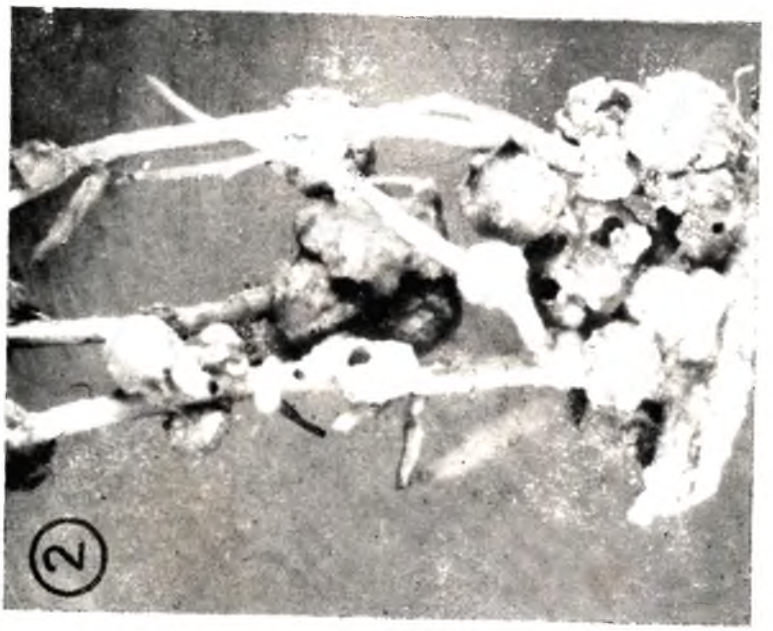

Fig. 2. Damaged nodules with grubs of (*Madurasia obscurella* Jacoby).

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BRIEF COMMUNICATION

CONTROL OF LITCHI MITE *ACERIA LITCHII* (KEIFER) WITH PARTICULAR REFERENCE TO EVALUATION OF PRE-BLOOM AND POST-BLOOM APPLICATION WITH DIFFERENT INSECTICIDES

D. D. SHARMA[1] & M. F. RAHMAN

Department of Zoology, L. S. College, Bihar University, Muzaffarpur, Bihar

(*Received 13 December 1980*)

Of the seven insecticidal treatments viz. monocrotophos 0.02%, carbaryl 0.3%, phosphamidon 0.05%, dimethoate 0.025%, Kelthane 0.05%, methyldemeton 0.025% and malathion 0.1% tested against litchi mite Kelthane was found to be highly effective in reducing leaf curling and enhancing fruit yield. Phosphamidon, dimethoate and methyldemeton were the next effective treatments in this trials.

(*Key words:* control of litchimite, *Aceria litchi*, insecticides)

The litchi mite *Aceria litchii* (Keifer) is a serious problem of litchi in Bihar where it is grown in plains as well as in hills. In India this reported to be the most damaging pest of litchi (MISHRA, 1912). LALL & RAHMAN (1975) reported that both the nymph and adult litchi mite suck the plant sap from the ventral surface of the young leaf bud with their stylet. As a result of this feeding activities, the injured tissue develops into abnormal growth of dense hair known as erinium. This erinium provides a good protection of the mite against wind and rain in addition to leaf buds mite also feed on flower buds and newly formed fruits. The infested flowers do not set fruit and fall prematurely. Earlier, nicotine sulphate, whale oil soap, sulpher, DDT, BHC, parathion, diazinon and dimethoate have been recommended for controlling the nymphs and adults (HIGGINS, 1917; GROFT 1921; RAY & DE, 1950; LALL & RAHMAN, 1975).

The experiments were conducted in a randomized block design on 10—12 year old litchi trees in a private orchard. Each experiment comprised of eight treatments with 8—10 litres of spray liquid on each tree to the point of drip off (Table 1). The observations recorded on the leaf curling and fruit weight are presented in Table 1.

Effect of treatment on leaf curling: It would be seen from the table that in all the three years the different insecticidal treatments reduced the leaf curling significantly over control. Kelthane, phosphamidon, dimethoate and methyldemeton treatments were on par and significantly superior to the rest of the insecticides in reducing leaf curl. The effectiveness of phosphamidon 0.05%, dimethoate 0.025% and methyldemeton 0.025% were next in order of merit in reducing leaf curling.

[1] Present address: Department of Entomology, Tirhut College of Agriculture, Dholi, Muzaffarpur (Bihar).

TABLE 1. Effect of Pre-bloom and Post-bloom sprays against litchii mite *Aceria litchii* (Keifer) on leaf curling and fruit weight.

Treatment	Conc %	Leaf curling % during			Av. fruit yield (kgs) during		
		1977	1978	1979	1977	1978	1979
Monocrotophos	0.02	23.48	31.20	27.07	48.03	49.94	44.82
Carbaryl	0.3	49.57	36.17	38.62	57.75	58.95	55.23
Phosphamidon	0.05	2.63	2.36	1.80	71.63	63.95	61.00
Dimethoate	0.025	3.02	4.33	3.99	72.68	68.14	71.75
Kelthane	0.05	1.42	1.57	1.20	82.43	76.73	87.13
Methyldemeton	0.025	5.06	5.28	5.49	70.38	65.49	65.54
Malathion	0.1	12.90	15.11	14.99	51.12	50.00	48.70
Control (water spray)	—	65.31	67.24	57.40	42.71	45.15	44.00
C D at 5%		10.06	13.41	6.82	12.76	15.71	17.12
C D at 1%		13.69	18.25	9.29	17.37	21.38	23.30

Effect on fruit yield: The data reveals that during all the three years, fruit yield due to treatment of kelthane, dimethoate, phosphamidon, methyldemeton and carbaryl were at par at 5% level. At 1% level of significance kelthane and dimethoate gave higher yield consistantly for all the three years.

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CONTROL OF SORGHUM SHOOT FLY, *ATHERIGONA SOCCATA* ROND. WITH INSECTICIDAL DUSTS ON FODDER SORGHUM

GURMEL S. SANDHU & G. S. DHALIWAL

Department of Entomology, Punjab Agricultural University, Ludhiana

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Four insecticidal dusts, i.e., BHC 10 per cent, fenitrothion 5 per cent, malathion 5 per cent and carbaryl 5 per cent were dusted once and twice at the rate of 25 kg/ha on April- and September-sown crops of sorghum fodder 7 and 14 days after germination for the control of sorghum shoot fly, *Atherigona soccata* Rond. Observations were recorded for the number of eggs laid and the dead hearts produced by the pest. In most of the observations one and two applications of BHC were the most effective treatments in reducing the number of eggs and dead hearts. However, malathion, carbaryl and fenitrothion were also as effective as BHC in some observations. Maximum yield of green fodder was obtained with two dustings of BHC in both the experiments. Of all the treatments, two applications of BHC dust gave the most consistent results for the control of the pest and also for the increased yield of the green fodder.

INTRODUCTION

Sorghum is an important fodder crop in the Punjab. The attack of sorghum shoot fly, *Atherigona soccata* ROND. makes the stand of the young crop poor and ultimately reduces the yield. The use of insecticidal granules for the control of the sorghum shoot fly, as recommended in the grain crop, is not economical in the fodder crop. KETKAR (1975) found that dusting the young crop with BHC dust proved as effective as seed treatment with 3 per cent carbofuran granules for the control of sorghum shoot fly. The cost of dusting the crop is within the means of the farmers raising the fodder crop of sorghum. It was, therefore, planned to study the effect of dusting the young crop with different insecticidal dusts on the infestation of the shoot fly and the yield of the green fodder.

MATERIAL AND METHODS

Four insecticidal dusts, i. e., BHC 10 per cent, fenitrothion 5 per cent, malathion 5 per cent and carbaryl 5 per cent at the rate of 25 kg/ha were applied on April— and September—sown crops to coincide with the maximum shoot fly infestations. However, carbaryl 5 per cent dust could not be included in the first experiment due to its late availability. Sorghum (variety *SL-44*, was sown in plots of 8 cm × 4 cm in lines 23 cm apart in randomised block design with three replications. There were two treatments for each dust, one with single application and second with two applications which were applied 7 and 14 days after germination, respectively. The dusts were applied with the help of hand-carried rotary duster to avoid drift into the adjoining plots. The seed rate and fertilizers were applied as per recommendations given in the Package of Practices for *kharif* crops of the Punjab Agricultural University (ANONYMOUS, 1977). The number of eggs were recorded twice 9 and 16 days after germination; and the dead hearts 13 and 20 days after germination. The yield of green fodder in different treatments was determined with the help of a spring balance at

75 per cent head stage of the crop. The data of different observations were subjected to the analysis of variance.

RESULTS AND DISCUSSION

Effect of different insecticidal dusts on the number of eggs laid on the crop

Nine days after germination and two days after dusting minimum number of eggs were found on the crop dusted with BHC 10 per cent, malathion 5 per cent and carbaryl 5 per cent (Table 1). Fenitrothion 5 per cent dust was less effective than these dusts. Sixteen days after germination minimum number of eggs were laid on the crop dusted twice with BHC dust in both the experiments. One dusting of fenitrothion, malathion and carbaryl were the least effective in reducing the number of eggs in most of the observations. However, the number of eggs were less in all the treated plots than in the untreated plots. SWAINE & WYATT (1954) in Tanzania dusted the crop five times with the dust containing 2.5 per cent DDT and 1.5 per cent *gamma*—BHC in the ratio of 1 to 1 at weekly intervals starting 9 days after sowing. KETKAR (1975) made two post-emergence applications of BHC 5 per cent dust on the crop in Maharashtra. In both these studies there was no difference in the number of eggs on the treated and untreated plants. The results of the present studies are at variance from their findings. In the present studies, the dead flies were observed in the treated plots, although their number was not counted. The less number of eggs on the treated plants seems to be due to the toxic as well as repellent effects of the insecticides on the flies. The fumigant action of BHC might have enhanced its repellent action.

Effect of different insecticidal dusts on the incidence of dead hearts in the crop

Thirteen days after germination, BHC 10 per cent dust was the most effective in reducing the dead hearts in the first experiment (Table 1). However, in the second experiment BHC 10 per cent, fenitrothion 5 per cent and carbaryl 5 per cent dusts were equally effective. Twenty days after germination, two applications of BHC dust was the most effective treatment in the first experiment; in the second experiment both one and two applications of BHC dust were the most effective treatments. One application of malathion and fenitrothion dusts were the least effective in both the experiments. However, the incidence of dead hearts was less in all the treated plots than in the untreated plots. The effectiveness of BHC alone or in combination with the other insecticides for reducing the number of dead hearts has been reported by a number of workers from African countries (SWAINE & WYATT, 1954; WHEATLEY, 1961; DAVIES & JOWETT, 1966). KETKAR (1975) in Maharashtra found that two applications of BHC 5 per cent dust at the rate of 25 kg/ha reduced the dead hearts from 34.80 per cent in the untreated plots to 16.84 per cent in the treated plots. The results of the present investigations are in line with the findings of the earlier workers.

CHACHORIA (1974) tried the sprays of carbaryl 0.2 per cent and malathion 0.1 per cent, with these treatments the dead hearts were significantly less than in the control and carbaryl treatment was better than malathion treatment. In the present studies also carbaryl was better than malathion.

Effect of different insecticidal dusts on the yield of green fodder

All the plots with insecticidal treatments gave more yield of green fodder than the yield of untreated control plot

TABLE 1. Number of sorghum shoot fly eggs and percentage of dead hearts on/in fodder crop of sorghum treated with insecticidal dusts (Mean of 3 replications).

Treatment (25 kg dust/ha)	(a) Single application of dusts			
	Number of eggs/100 plants (9 days after germination)		Percentage of dead hearts (13 days after germination)	
	I Experiment*	II Experiment*	I Experiment	II Experiment
BHC 10 per cent	8.66[a]**	5.00[a]	7.3 (15.70)[a]	13.7 (21.73)[a]
Fenitrothion 5 per cent	16.00[b]	11.00[b]	13.2 (21.26)[b]	16.0 (23.56)[ab]
Malathion 5 per cent	13.66[ab]	7.66[a]	11.7 (20.04)[b]	17.6 (24.75)[b]
Carbaryl 5 per cent	—	6.33[a]	—	15.2 (22.92)[ab]
Control	33.66[c]	38.66[c]	29.9 (33.17)[c]	42.2 (40.50)[c]
CD (p = 0.05)	5.97	3.16	(3.52)	(2.01)

	(b) Single and two applications of dusts			
	Number of eggs/100 plants 16 days after germination)		Percentage of dead heart (20 days after germination	
	I Experiment	II Experiment	I Experiment	II Experiment
BHC 10 per cent (One application)	7.00[abc]	5.00[c]	15.3 (22.99)[b]	16.1 (23.63)[ab]
BHC 10 per cent (Two applications)	3.00[a]	0.00[a]	6.3 (14.61)[a]	13.4 (21.49)[a]
Fenitrothion 5 per cent (One application)	14.33[d]	7.66[d]	22.5 (28.33)[c]	21.3 (27.48)[cd]
Fenitrothion 5 per cent (Two applications)	8.66[bc]	2.00[b]	13.7 (21.67)[b]	18.3 (25.31)[bc]
Malathion 5 per cnt (One application)	10.00[cd]	7.33[d]	20.9 (27.22)[c]	22.6 (28.37)[d]
Malathion 5 per cent (Two applications)	5.00[ab]	2.66[b]	15.7 (23.39)[b]	18.2 (25.29)[bc]
Carbaryl 5 per cent (One application)	—	7.00[d]	—	19.0 (25.82)[bc]
Carbaryl 5 per cent (One application)	—	2.33[b]	—	17.0 (24.31)[b]
Control	19.66[e]	17.00[e]	37.9 (38.01)[d]	48.2 (43.98)[e]
CD (p = 0.05)	4.35	1.86	(2.75)	(2.65)

* I and II experiments were conducted in 1978 on April-and September-sown crops respectivfly.

** Figures with the same super script letter do not differ significantly at 5 per cent level.

TABLE 2. Yield of green fodder of sorghum treated with insecticidal dusts (Mean of 3 replications).

Treatment (25 kg dust/ha)	First experiment (April, 1978)		Second experiment (September, 1978)	
	Yield in qtl/ha	Percentage increase in yield over control	Yield in qtl/ha	Percentage increase in yield over control
BHC 10 per cent (One application)	798.94^{ab}*	27.19	172.91^{c}	32.81
BHC 10 per cent (Two applications)	814.56^{a}	29 68	241.66^{a}	68.82
Fenitrothion 10 per cent (One application)	758.31^{d}	20.73	209.38^{b}	60.83
Fenitrothion 10 per cent (Two 2pplications)	783.31^{bc}	24.71	208.13^{b}	60.03
Malathion 5 per cent (One application)	767.69^{cd}	22.19	195.81^{b}	50.41
Malathion 5 per cent (Two applications)	773.94^{cd}	23.21	209.38^{b}	60.83
Carbaryl 5 per cent (One application)	---	—	241.66^{a}	68.82
Carbaryl 5 per cent (Two applications)	—	—	204.16^{b}	56.82
Control	628.13^{e}	—	130.19^{d}	—
CD ($p = 0.05$)	23.66	—	20.50	—

* Figures with the same letter do not differ significantly at 5 per cent level.

in both the experiments (Table 2). Maximum yields of green fodder were obtained with two dustings of BHC in both the experiments, one dusting of BHC in the first experiment and one dusting of carbaryl in the second experiment. The increase in yield with two applications of BHC was the most consistent. This treatment increased the yield of green fodder from 29.68 to 68.82 per cent and was also the most effective in reducing the number of eggs and the dead hearts in the two experiments. The review of literature indicates that the insecticidal dusts had not been tested earlier for their effect in increasing the yield of fodder by controlling the shoot fly. However, reports are available where increases in yield of dry fodder from 70 to 282 per cent have been reported by the application of phorate granules to the grain crop (THOBBI *et al.*, 1968; KULSHRESHTHA *et al.*, 1969). JOTWANI *et al.*, (1971) reported 3.11 to 17.04 per cent increase in yield of sorghum fodder with the application of phorate at 2 kg ai/ha at sowing time. These variations in the increase of fodder yield were due to the degree of shoot fly infestation in the experimental plots.

It is, therefore, suggested that sufficient increase in yield of fodder can be obtained by chemical control of shoot fly especially with BHC dust. This treatment is quite cheap and can be economically adopted by the farmers growiug fodder crop of sorghum. However, such chemical control should be resorted to when there is appreciable infestation by the shoot fly in the early stage of the crop.

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DEGENERATION OF THORACIC MUSCLES IN SEXUAL FORMS OF *ODONTOTERMES ASSMUTHI* HOLMGREN (TERMITIDAE : ISOPTERA) FOLLOWING SWARMING AND COLONY ESTABLISHMENT

S. BASALINGAPPA

Department of Zoology, Karnatak University, Dharwad, India - 580 003

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In the freshly swarmed reproductives of *Odontotermes assmuthi* Holmgren the thoracic muscles were found very well-developed occupying the major portion of thoracic cavity, whereas, in the roval couples, they were found reduced to only a few strips. Such degeneration of the thoracic muscles was the result of sarcolysis through which these termites subsisted during the critical period of starvation, reproduction and the development of their first batch of progeny. Thoracic muscle degeneration affected equally in both sexes within about 120-150 days.

(*Key words:* Thoracic muscle degeneration, sexuals, termite, *Odontotermes assmuthi*, swarming, colony formation)

INTRODUCTION

IMMS (1963) cited reports of thoracic muscle degeneration in the royal couple while establishing a colony. SNYDER (1948) and GRASSE (1949) have stated that the termite sexuals during the period of colony establishment subsisted upon the stored food available in the fat-body and flight muscles. According to NOIROT (1969) degeneration of flight muscles was a progressive one, taking place slowly in several years and played a minor role in nutrition contrary to the situation in ants. Present report records the observations on the muscle degeneration in *O. assmuthi*.

MATERIALS AND METHODS

The materials consisted of freshly-swarmed sexuals as well as the queens and kings recovered from laboratory maintained and field colonies. All these types were first dissected out and their thoracic muscles isolated and weighed.

RESULTS AND DISCUSSION

The thoracic muscles were very well-developed and weighed 10—13.7 mg in male and 8.8—10.5 mg in female dealates. In the established queens and kings from field and laboratory-maintained colonies, the muscles were found much reduced to only a few strips and weighed 0.6—0.8 mg and 0.41—0.51 mg respectively. The depletion of muscles in the royal couples suggested that the paired dealates utilised such muscles during their sustained starvation. It was observed that the paired reproductives after pairing and establishing a royal cell of their own under laboratory conditions, spend 120—150 days till they get adult workers from their first batch of eggs to feed them. Since pairing, the dealates were not at all provided with any food material. Hence, it is strongly doubted that during the long period of sustained starvation the royal pair

subsisted on the material stored up in the fat-body and thoracic muscles and supplied through autolysis. As a result of utilisation of fat from fat-body, the fat was found in a low quantity (26%) in the queens and kings than those of the freshly collected dealates (48%) from whom they have developed (BASALINGAPPA, 1970).

Although several observers have reported about the thoracic muscle degeneration that took place in the royal pairs, only NOIROT (1969) mentioned that progressive degeneration lasted for several years. But in the case of the royal couples of the laboratory-maintained colonies of *O. assmuthi*, it was found that the thoracic muscle degeneration reached its maximum in about 150 days, by which time the workers from the first batch of eggs reached adult condition and were in a position to feed the royal couples. It is doubtful if NOIROT'S observation is factually correct, since in any termite colony, the subsistence of the royal pairs through sarcolysis need not go beyond the time needed for the first set of workers to attain adult stage.

Parallel cases of subsistence through sarcolysis during certain critical times are on record from ants like *Lasius niger* (WHEELER, 1960) and *Formica fusca* (TONAPI, 1958). Similar records are available from *Culicidae* (HOCKING, 1952), aphids (JOHNSON, 1953) and even from fishes like salmon (WHEELER, 1960) and *Hilsa sp.* Recently, NAIR & PRABHU (1979) have shown the histolysis of flight muscles in the mated females of *Dysdercus cingulatus* during gonotrophic cycle suggesting the degeneration of flight muscles for ovarian growth and egg formation. In all such cases, degeneration of muscles is correlated with the needs of egg-laying. NOIROT, who studied termites in this respect, reported that the phenomenon was more marked in the case of females than males and took place in several years. But in *O. assmuthi*, it was found that degeneration affected within 150 days equally in both the sexes which is reasonable to assume so, since both the queen and king were reproductively active and moreover remained unfed till the first batch of workers reached maturity.

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ESTIMATION OF AVOIDABLE LOSSES CAUSED BY THE EARHEAD CATERPILLARS ON SORGHUM AND THEIR CONTROL

PREM KISHORE & M. G. JOTWANI

Division of Entomology, Indian Agricultural Research Institute, New Delhi - 110 012

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Field trials were conducted for 3 years (1977—'79) to determine the losses caused by earhead caterpillars on sorghum and to compare the relative efficacy of some of the insecticides found to be effective in preliminary trials. Data on decrease in population of earhead caterpillars showed significant reduction in all the insecticidal treatments, the order of efficacy being endosulfan > BHC > isofenphos > phenthoate dust > malathion > quinalphos > carbaryl + molasses > phenthoate spray. The average avoidable loss of grain in the insecticidal treatments ranged from 1.71 to 19.61 per cent as against 44.35 per cent in control. Endosulfan dust followed by BHC and phenthoate dusts and isofenphos spray gave better yields than other insecticides. Approximate net monetary benefit was also found to be higher in endosulfan 4% dust (Rs. 1954.25) followed by BHC 10% dust (Rs. 1927.00) and phenthoate dust (R. 1721.80).

(Key words: loss estimation, earhead caterpillar, sorghum, control)

Sorghum earhead caterpillars, which until recently were considered to be sporadic pests of little economic importance have assumed major pest status in some areas of Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh, Gujarat and Delhi. They are especially serious on new high yielding cultivars with compact earheads. The different species found feeding on maturing grains are: *Eublemma silicula* SWINHOE, *Heliothis armigera* HUB., *Dichocrocis punctiferalis* GN., *Cryptoblabes gnidiella* MILL., *Porthesia xanthorrhoea* KOLL., *Ephestia cautella* WLK. and *Sitotroga cerealella* OLIV.

Out of the above listed species first five are more common. The larvae feed on the inner layers of soft grains and can be detected by the presence of frass, consisting of faeces and broken grains. There may be even more than 20 larvae of different species on a single earhead, especially of *Eublemma* and *Cryptoblabes* spp. Some work on chemical control of these pests has been reported by JOTWANI & YOUNG (1972) and TALEY & DONGARDEO (1977). The present studies were undertaken to collect data on the extent of losses caused by the complex of earhead caterpillars and to determine relative efficacy of different insecticides for the control of these pests.

MATERIAL AND METHODS

The trials were conducted at farm area of the Indian Agricultural Research Institute, New Delhi from 1977 to 1979 in randomized block design. The details about number of treatments, replications, plot size etc., are given in Table 1. Hybrid *CSH-5* was grown for these studies and all the plots (including control) were effectively protected from shootfly and stem borer. All the insecticides, exceept isofenphos, which was included in the trials conducted in 1978 and

TABLE 1. Details of experiments conducted during 1977 to 1979 *Kharif* seasons.

Sl No.	Year	Area of subplot (sq. m.)	No. of rows	Length of a row (metre)	No. of treatments	No. of replications	Date of sowing	Date of treatment
1.	1977	11.25	5	3	8	4	4-7-77	16-9-77
2.	1978	11.25	5	3	9	4	3-7-78	14-9-78
3.	1979	11.25	5	3	9	4	4-7-79	18-9-79

1979 selected on the basis of preliminary trials carried out in 1975—76. The insecticidal application was given 20 days after earhead emergence. The insecticides and the doses used are listed in Table 2.

Observations on the population of earhead caterpillars were taken before the treatment and again three days after treatment on 5 randomly selected earheads from each plot. Average percentage decrease in population of earhead caterpillars was calculated for each insecticidal treatment. At the time of harvest, yield of grain was recorded from each plot and was converted to yield in quintals per hectare. The increase in grain yield over control was calculated for each treatment. Also percentage avoidable loss due to earhead caterpillars was determined by taking the highest yield in the best treatment as expected yield potential.

RESULTS AND DISCUSSION

Data recorded on incidence of earhead caterpillars prior to insecticidal treatment showed that average population of earhead caterpillars was 10.50, 20.75 and 22.75 per five earheads during 1977, 1978 and 1979 respectively. Insecticidal application was given at that stage and the relative efficacy of different insecticides was determined by determining reduction in larval population as well as protection from further infestation as exhibited by loss in grain yield. The results are presented in Table 2.

The average percentage decrease in population of earhead caterpillars due to insecticidal treatments, recorded three days after application ranged from 50.00 to 82.50, 59.79 to 92.30 and 41.46 to 88.04 in 1977, 1978, and 1979 respectively, while in the control, where no treatment was given, it increased by 49.35, 72.94 and 41.75 per cent during three years respectively. Significant differences were observed between the treatments during 1977 and 1978 trials, differences between endosulfan and BHC were not significant. Similarly phenthoate dust treatment was not statistically inferior to BHC dust during 1978 and 1979. The order of efficacy of insecticides on the basis of percentage reduction in caterpillar population for pooled averages was endosulfan > BHC > isofenphos > phenthoate dust > malathion > quinalphos > carbaryl + molasses > phenthoate spray.

Grain yield in all the insecticidal treatments was significantly higher than control, during the three years. There were significant differences between the insecticidal treatments also. Endosulfan and BHC dust were significantly better than carbaryl + molasses, phenthoate and quinalphos sprays. However, phenthoate dust was at par with endosulfan and BHC dusts. Differences between other insecticides were not significant except in the last year (1979) when phenthoate and quinalphos sprays proved to be inferior to other insecticidal treatments but were better than control.

The maximum grain yield on the basis of pooled averages was 46 23 q/ha

TABLE 2. Relative efficacy of different insecticides for the control of earhead caterpillars.

Sl No.	Treatment	1977				1978				1979				Pooled average			
		Av. % larval population	Av. grain yield (Q/ha)	Increase in grain yield over control (Q/ha)	% avoidable loss	Av. % larval population	Av. grain yield (Q/ha)	Increase in grain yield over control (Q/ha)	% avoidable loss	Av. % larval population	Av. grain yield (Q/ha)	Increase in grain yield over control (Q/ha)	% Avoidable loss	Av. % larval population	Av. grain yield (Q/ha)	Increase in grain yield over control (Q/ha)	Av. % Avoidable
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	Endosulfan 4% dust @ 15 kg/ha	(−)82.50	43.00	19.00	0.00	(−)82.30	43.05	18.80	0.00	(−)88.04	52.65	23.80	0.00	(−)87.61	46.23	20.53	0.00
2.	BHC 10% dust @ 15 kg/ha	(−)79.94	42.50	18.50	1.16	(−)88.50	42.85	18.60	0.47	(−)82.55	50.80	21.95	3.51	(−)83.64	45.38	19.68	1.71
3.	Malathion 5% dust @ 15 kg/ha	(−)50.00	39.00	15.00	9.30	(−)74.39	39.25	15.00	8.84	(−)75.28	47.95	18.10	8.93	(−)66.55	42.06	16.36	9.02
4.	Phenthoate 2% dust @ 15 kg/ha	(−)69.04	40.50	16.50	5.81	(−)82.27	41.75	17 50	3.02	(−)80.68	48.78	19.93	7.35	(−)77.33	43.67	17.97	5.39
5.	Carbaryl + molasses (40LV) @ 0.2% spray	(−)50.00	38.00	14.00	11.63	(−)65.11	38.10	13.85	11.51	(−)73.17	46.00	17.15	12.63	(−)62.76	40.70	15.00	11.92
6.	Phenthoate (50% EC) @ 0.05% spray	(−)52.17	39.20	15.20	8.84	(−)59.79	36.00	11.75	16.38	(−)41.46	34.95	6.10	33:62	(−)50.14	36.71	11.01	19.61
7.	Quinalphos (25% EC) @ 0.5% spray	(−)54.05	39.40	15.40	8.37	(−)72.28	38.00	13.75	11.73	(−)68.23	39.56	10.71	24.86	(−)64.85	38.98	13.28	14.98
8.	Isofenphos (50% EC) 0.05% spray	—	—	—	—	(−)80.63	39.45	15.20	8.37	(−)80.45	48.00	19.15	8.83	(−)80.45	43.72	17.17	8.60
9.	Control (No treatment)	(+)49.35	24.00	—	44.19	(+)72.94	24.25	—	43.67	(+)41.75	28.85	—	45.20	(+)54.68	25.70	—	44.35
	SE(m)±	1.36	1.02			2.17	1.44			1.08	1.66						
	CD at 5%	3.97	2.99			6.33	4.20			3.10	4.77						

(−) decrease in larval population (+) increase in larval population

TABLE 3. Increase in grain yield and approximate monetary benefit obtained by the control of earhead caterpillars with different insecticides.

Sl No.	Insecticide	*Increase in yield over control (Q/ha)	Cost of grain saved (rupees)	Cost of insecticide + labour (rupees)	Net monetary benefit (rupees)
1.	Endosulfan dust	20.53	2053.00	98.75	1945.25
2.	BHC dust	19.68	1968.00	41.00	1927.00
3.	Malathion dust	16.36	1636.00	65.90	1570.10
4.	Phenthoate dust	17.97	1797.00	75.20	1721.80
5.	Carbaryl + molasses	15.00	1500.00	205.00	1295.00
6.	Phenthoate spray	11.01	1101.00	62.00	1039.00
7.	Quinalphos spray	13.28	1328.00	98.00	1230.00
8.	Isofenphos spray**	17.17	1717.00	—	—

* Mean for 1977 to 1979 except for isofenphos which is of 1978 and 1979.

** Price not available.

in endosulfan, closely followed by BHC dust with 45.38 q/ha. The average grain yield in other insecticidal treatments ranged from 36.71 to 43.72 q/ha while it was minimum (25.70 q/ha) in control.

The increase in grain yield over control was maximum in endosulfan dust in all the years and ranged form 18.80 to 23.80 q/ha followed by BHC dust where it ranged from 18.50 to 21.95 q/ha. On the basis of pooled averages the increase in yield over control ranged from 11.01 to 20.53 q/ha in other insecticidal treatments.

The avoidable grain loss, calculated by taking the highest yield obtained from best treatment as possible yield potential ranged between 1.16 to 11.63, 0.47 to 16.38 and 3.51 to 33.62 per cent in insecticidal treatments during 1977, 1978 and 1979 as against 44.19, 43.67 and 45.20 per cent in control during the respective years. Taking pooled averages, it ranged between 1.17 to 19.61 per cent in insecticidal treatments as against 44.35 per cent in control.

The data for three years have clearly indicated that 4% endosulfan and 10% BHC dusts gave better protection against earhead caterpillars followed by 2% phenthoate dust and isofenphos (50% EC) spray. However, all the insecticides tried significantly reduced the caterpillar population and gave better yield than control.

From the increase in yield due to the control of earhead caterpillars approximate benefit has been calculated by taking the market price of sorghum grain as rupees one hundred per quintal. From the value of increased grain yield, the costs of insecticides and labour have been deducted, thereby getting the net benefit for each treatment. Data on monetary benefit are presented in Table 3.

It is seen from Table 3 that the maximum monetary benefit was obtained from endosulfan dust, followed by BHC and phenthoate dusts and minimum from phenthoate spray

DETHE & SHIROLE (1980) have reported that they could not detect any residues of endosulfan 4% dust and BHC 10% dust in grains or threshed earheads after sixty days. Two applications of these insecticides were given in their trials. It is, therefore, indicated that one application given in the present trials may not leave any residues of the two insecticides after harvest.

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FOOD UTILIZATION STUDIES OF *CORCYRA CEPHALONICA* AND *EPHESTIA CAUTELLA*

G. K. SHARMA, K. L. JAIN & B. L. PAREEK[1]

Department of Entomology, College of Agriculture, University of Udaipur, Udaipur, India - 313 001

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The food utilization profiles of the rice moth, *Corcyra cephalonica* Staint., and the almond moth, *Ephestia cautella* (Walker), were studied on five of their common hosts, namely maize *(Zea mays* L.*)*, wheat *(Triticum aestivum* L.*)*, sorghum *(Sorghum vulgare* Pers.*)*, rice *(Oryza sativa* L.*)* and groundnut *(Arachis hypogeae* L.*)*. The food quality was measured by calculating approximate digestibility (AD) and efficiency of conversion of ingested food (ECI) and digested food (ECD) to body substance. The order of food utilization was; sorghum, groundnut, rice, maize and wheat for *C. cephalonica*, and sorghum, maize, groundnut, wheat and rice for *E. cautella*.

(*Key words*: Food utilization, host preference, *Corcyra cephalonica*, *Ephestia cautella*)

INTRODUCTION

The rice moth, *Corcyra cephalonica* STAINT., and almond moth, *Ephestia cautella* (WALKER), are serious lepidopterous pests of stored commodities. These polyphagous pests have some common hosts (ATWAL, 1976), the order of preference of five of which used in an earlier host preference study were: sorghum, maize, groundnut, rice and wheat for *C. cephalonica*, and sorghum, maize, groundnut, wheat and rice for *E. cautella* (SHARMA *et al*, 1978). Like in other nutritional studies, the parameters used for studying the host preference were developmental periods, survival to pupal and adult stages, and pupal weights. However, food utilization measurements, which include weight gained, quantity of food eaten, the digestibility of food, and the efficiency of conversion of food to body substance, play an important role in insect nutrition, and could be used for determining the host preference in terms of the efficiency of a food. Food utilization studies have mostly been conducted on phytophagous insects, and little work has been done on food consumption by stored grain pests (RAO, 1954; KRISHNA & SAXENA, 1962; BHATTACHARYA & WALDBAUER, 1970; GUPTA & RADHAKRISHNAMURTY, 1971; SINGH *et al*, 1972; WALDBAUER & BHATTACHARYA, 1973). The present study was undertaken to confirm the earlier host preference findings for *C. cephalonica* and *E. cautella* (SHARMA *et al*, 1978) by another method, namely by measuring the food utilization indices.

MATERIALS AND METHODS

Sorghum, which was found to be the most preferred host for both *C. cephalonica* and *E. cautella* (SHARMA *et al.*, 1978), was used for maintaining the insect cultures. The five hosts *i. e.*, maize *(Zea mays* L.*)*, rice (*Oryza sativa* L.*)*, sorghum (*Sorghum vulgare* PERS*)*, wheat (*Triticum aestivum* L.*)*, and groundnut *(Arachis hypogeae*

[1]Present Address—Department of Entomology, College of Agriculture, Jobner - 303 329 (Rajasthan).

L.), which were used for the previous host preference studies, were also used in the present investigation.

Ten 20-day-old larvae of both the insects were starved for 24 hr, weighed, and introduced into 10 cm petridishes containing 20.0 g of individual food grain. The petridishes, after closing tightly with rubber bands, were kept in an incubator maintained at 28±1°C and 75 ± 5 per cent relative humidity. Each experiment had three groups of 10 larvae each and the pooled data were evaluated by analysis of variance. The utilization profiles for each insect were studied for 72 hr. The dry weights of the introduced larvae were calculated on the basis of the mean dry weight percentage of three aliquots (each with 10 larvae) which had been dried to a constant weight at 100° C. Similarly, the dry weights of the introduced foods were calculated on the basis of the mean percentage dry weight of three aliquots (containing 20.0 g of each host-food) which had been dried to a constant weight at 100° C.

After 72 hr of feeding the larvae were removed from the petridishes and were again starved for 24 hr, so as to devoid their guts of residual faecal material. The faeces collected during starvation period was added to the faeces which was separated from the left-over food. The larvae were dried to a constant weight at 100°C and weighed to determine the weight gained during the 72 hr feeding period. The left-over food and faeces were separated manually, dried to a constant weight at 100°C, and weighed.

All the weights (food eaten, weight gained and faeces produced) were expressed as mean dry weights per group for calculating the utilization indices. The efficiency of conversion of ingested food to body substance (ECI), approximate digestibility (AD), and efficiency of conversion of digested food to body substance (ECD) were computed as described by WALDBAUER (1968).

RESULTS AND DISCUSSION

For both the insects, the variation in AD values for all the five host-foods was much less as compared to ECI and ECD values (Table 1), proving thereby that the differences in the food quality were not in their digestibility but in their efficiency of conversion of digested/ingested food to body substance. On the basis of three parameters namely AD, ECI and ECD, sorghum was found to be the most nutritious food for both the insects. The AD value for the sorghum was the highest among host-foods, however, it was comparable to groundnut for *C. cephalonica* and to maize and groundnut for *E. cautella* respectively. The ECI and ECD values were significantly higher, when the larvae were fed on sorghum as compared to the ones fed on the other host-foods. This is in agreement with the earlier host preference study (SHARMA *et al.*, 1978), where sorghum was also found to be the most preferred food for both the insects.

For *C. cephalonica,* the food quality order for other hosts was groundnut, rice, maize and wheat. However, groundnut and rice were found to be third and fourth in order of food preference in the earlier host-biology study (SHARMA *et al.*, 1978). This discrepancy was due to the fact that, although the larvae reared on groundnut and rice were slow in their development, they had quite high pupal weights, thereby indicating high food consumption. Maize, which was second only to sorghum in food preference in the host-biology study (SHARMA *et al.*, 1978), came out fourth in the present study. Lower pupal weights of larvae reared on maize (SHARMA *et al.*, 1978, explain its poor rating from consumption point of view.

For *E. cautella*, the order of food utilization was sorghum, maize, groundnut wheat and rice, which was similar to the one obtained from earlier host-biology study (SHARMA *et al.*, 1978). The similarity in host preference findings by both host-biology and food utilization studies for *E. cautella*, and minor variations for *C. cephalonica*, suggest that the latter method

TABLE 1. Mean food utilization profiles of 20-day-old *C. cephalonica* and *E. cautella* larvae fed for 72 hr on different host-foods*.

Host	Food eaten (mg)	Weight gained (mg)	Faeces produced (mg)	AD	ECI	ECD
			C. cephalonica			
Sorghum	299.33	34.05	39.93	86.66[a]**	11.38[a]**	13.13[a]**
Maize	363.67	25.05	68.03	81.29[b]	6.89[b]	8.47[b]
Groundnut	325.60	30.20	46.07	85.67[a]	9.28[c]	10.83[c]
Rice	348.20	27.84	56.10	83.89[c]	8.00[d]	9.53[d]
Wheat	401.10	20.05	79.13	80.27[b]	5.00[e]	6.23[e]
			E. cautella			
Sorghum	220.33	12.94	27.67	87.45[a]**	5.87[a]**	6.72[a]**
Maize	295.33	9.78	39.00	86.79[a]	3.31[b]	3.82[b]
Groundnut	271.27	8.19	35.67	86.85[a]	3.02[c]	3.48[c]
Rice	132.20	0.82	25.67	80.58[b]	0.62[d]	0.77[d]
Wheat	335.97	4.96	59.83	82.19[c]	1.48[e]	1.80[e]

* Weights and indices are expressed as means per group for 3 groups of 10 larvae each.
AD, approximate digestibility; ECI, efficiency of conversion of ingested food to body substance; ECD, efficiency of conversion of digested food to body substance.

** Values not followed by same letter are significantly different ($P<0.05$).

could be used effectively for determining the host preference of an insect. Moreover, the latter method has an advantage since results can be obtained faster than in the host-preference method wherein one has to wait till adult emergence.

The larvae of both the insects used for determining the food utilization were of the same age (20-day-old), but due to the longer larval period of *C. cephalonica* as compared to *E. cautella* (ATWAL, 1976), the former larvae were instarwise younger as compared to the latter ones. Early instar larvae were found to consume more food per unit weight than the older ones (GUPTA & RADHAKRISHNAMURTY, 1971). This higher food consumption per unit weight by instarwise younger larvae resulted, for all the five host-foods, in higher ECI and ECD values for *C. cophalonica* as compared to *E. cautella*.

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INFLUENCE OF WATER STRESS IN THE HOST PLANT ON THE MUSTARD APHID *LIPAPHIS ERYSIMI* (KALTENBACH)

I. C. CHADDA & RAMESH ARORA[1]

Department of Entomology, Punjab Agricultural University, Ludhiana, India

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A study of the concentration of the amino acids in the leaf sap of the radisn, *Raphanus sativus* L. plants grown under three soil-water regimes (8—10, 5—7 and 2—4%) and in the honeydew of the aphids reared on these plants showed that the concentration of amino acids, especially the acidic amino acids increased significantly under lower soil-water regimes. Nutritional imbalance created by this high concentration coupled with increasing burden on the excretory mechanism of the aphid are mainly responsible for the reduction in the fecundity of the aphid under such conditions. This is further confirmed by the significant reduction (0.01539 to 0.01016 μl) in the droplet size of the honeydew of the mustard aphid with decrease in soil water regime. The significant reduction in the frequency of excretion (32.2 to 16.6 droplets/aphid day) with decrease in soil-water regime from the highest to the lowest level indicates that the aphid is unable to suck enough quantity of phloem sap because of reduced turgor pressure in the plant.

(Key words: mustard aphid, *Lipaphis erysimi*, water stress, host plant)

Many aphid species appear to depend upon turgor pressure of the host plant for maintaining their normal rate of sap intake (KENNEDY *et al*, 1968; MITTLER, 1958; AUCLAIR, 1963) and are adversely effected by water shortage in the host plant. According to SIDHU & KAUR (1976), the mustard aphid, *Lipaphis erysimi* (KALTENBACH) also appears to depend upon the turgor pressure of the host plant for its feeding and its fecundity is adversely effected by the increasing water stress in the host plant. The present study is an attempt to analyse some of the factors which might have been responsible for this reduction in the fecundity of this aphid under the reduced water supply to the host plant.

[1] Present address:—Punjab Agricultural University Operational Research Project, Court Road, Muktsar, India.

MATERIAL AND METHODS

Radish (*Raphanus sativus* L.) var. *S-white* plants were grown in enamelled pots 6×6″ each with a small hole at the bottom. Each pot was filled with 2.5 kg of soil whose water holding capacity and permanent wilting coefficient were determined earlier. The two values were found to be 11% and 2% respectively. The plants were maintained at three soil-water regimes, i. e. 8—10, 5 - 7 and 2—4 per cent. The plants were weighed twice a day and were irrigated when the water content reached the respective lower level. While ascertaining the water content levels of the soil, a radish plant approximately equivalent to the potted plant in mass was uprooted from the nursery and placed along with weights on one of the two pans of the scale to counteract the influence of the quantity of water to be added.

Extraction and purification of the leaf sap

The leaf sap was extracted by using centrifuge tubes slightly narrowed at the middle portion. The second leaf of the 4-leaf stage radish plant in each treatment was removed and kept on a thin layer of glasswool in the centrifuge tube

which was then kept in a refrigerator for 4 hr. and later centrifuged in an international centrifuge at 1500 r. p. m. for 30 minutes for extracting the sap.

For purification 3 ml of 95% ethanol was added to 2 ml of the leaf sap and centrifuged for 20 minutes. The supernatent was collected along with two washings of the residue each with 3 ml of 95% ethanol. The supernatent was then heated at 40—45°C in a waterbath to reduce its volume to one-third. To this solution 3 times its volume of chloroform was added. The solution was centrifuged to remove the fat layer and the process was repeated till there was no formation of separate layer and the aliquot was used for the estimation of amino acids in the leaf sap.

Estimation of amino acids in the leaf sap

The amino acids were estimated by employing two dimensional paper chromatography. 0.2 ml of the purified sap was spotted on a Whatman No. 1 chromatographic sheet and the chromatogram was run first towards the shorter side using phenol: water (4:1 v/v) as solvents. It was dried and run again towards the longer side using *n*-butanol:glacial acetic acid : water (4:1:5 v/v). The chromatogram was then dried and sprayed with 0.2% ninhydrin in acetone with the help of an atomizer. The spots were developed by keeping it in an oven at 60°C for 10 minutes. The different amino acids were identified by comparing these spots with those of known amino acids processed under similar conditions. The individual spots were removed by cutting the pieces of the paper from the chromatographic sheet and were eluted in 7 ml of 70% ethanol. The optical density of these samples was recorded using a Spectronic-20 photocolorimeter at 570 nm except for asparagine and proline whose optical density was recorded at 480 nm. The quantity of various amino acids was calculated with refernce to the standard curve of glycine except in case of asparagine and proline. The quantity of these two amino acids was calculated with reference to the standard curve of the relevant amino acid.

Collection of honeydew

About one hunderd last instar nymphs of the mustard aphid reared on each soil-water regime were released on the undersurface of second leaf of the 4-leaf stage radish plants. A glass plate covered with parafilm M was placed below this leaf. The honeydew droplets were picked immediately with a graduated capillary tube and counted to determine the quantum of excretion. The honeydew was preserved in 70% ethanol in the refrigerator until it was required for analysis.

Frequency of honeydew excretion

The honeydew of two newly emerged aphids was collected for the first 4 days of the pre-reproductive period on Whatman filter paper discs of 9 cm diameter. These paper discs were fixed to the needles of time pieces especially designed for this purpose and were placed beneath the leaf infested with aphids. Each paper disc was replaced by another on after 12 hr in all the six replications in each treatment. The honeydew droplets based on the presnce of aminoacids and amides were identified by spraying with 0.02% ninhydrin in acetone and then heating the paper in an oven at 70°C for 10 minutes.

Estimation of amino acids in the honeydew

15 μl of honedew sample stored in 70% ethanol was spotted on the chromatographic sheet and analysed by the method described earlier for leaf sap analysis.

RESULTS AND DISCUSSION

Concentration of amino acids in the leaf sap and honeydew

The concentration of amino acids in the plant sap increased with decrease in soil-water regime (increasing water stress) (Table 1). The increase in the concentration of acidic amino acids and amides was high compared to the increase in the concentration of other amino acids correspondingly. This was manifested by the ratios of 1:0.40; 1:0.47 and 1:0.80 of the concentration of other amino acids versus concentration of the acidic amino acids and amides in the leaf sap under three treatment respectively. The acidic amino acids and amides got further accumulated in the alimentary canal of the aphid and surpassed the concentration of other amino acids as revealed by their concentration in the honeydew of the

TABLE 1. Concentration of the acidic amino acids, amides and other amino acids in the leaf sap of radish plants grown under three different levels of water stress and in the honeydew of the mustard aphid, *Lipaphis erysimi* (KALT.) reared on these plants.

Amino acids	Concentration of amino acids (mg/100 ml)					
	Leaf sap			Honeydew		
	Treatments					
	A	B	C	A	B	C
Acidic amino acids	21	39	73	483	559	846
Amides	74	76	130	2720	2860	2893
Other amino acids	234	244	251	1725	2774	2849

Treatment A : 8—11% soil-water regime.
B : 5— 7% soil-water regime.
C : 2— 4% soil-water regime.

aphids reared on these plants. The relatively higher concentration of acidic amino acids and amides lead to imbalance in the nutrients of the aphid which inturn could result in poor nourishment of the aphid and its lower fecundity. Moreover, increase in the concentration of amides increases the burden on the excretory mechanism of the aphid as excretion in this species was largely to be found in the form of amides (SIDHU & PATTON, 1970). This is also borne out by the significant reduction in the volume of honeydew droplets with increasing water stress in the plant (Table 2) as the aphid under such conditions could not afford to wait for the accumulation of these waste products in the gut as is the case under normal conditions.

Frequency of excretion

As is clear from Table 3, the mean frequency of excretion decreased significantly with decreasing soil-water regime. The mustard aphid appears to depend upon the turgor pressure of the host plant for feeding (SIDHU & KAUR, 1976). So in this

TABLE 2. Mean volume of honyedew of Vth instar mustard aphid reared on plants grown at three soil-water regimes.

Soil-water regime (%)	Volume of honeydew droplet* (microlitres)
8—10	0.01539
5— 7	0.01244
2— 4	0.01016
C. D. (P = 0.05)	0.00198

*Mean of 10 replications.

TABLE 3. Mean frequency of excretion of honeydew droplets by mustard aphids reared on plants grown at three soil-water regimes.

Soil-water regime(%)	Frequency of excretion/ aphid/day*
8—10	32.2
5—7	24.2
2—4	16.6
C.D. (p = 0.05)	4.17

*Mean of six replications

case the aphid could not suck enough sap with increasing water stress in the plant under low soil-water regime and it resulted in a corresponding reduction in the frequency of excretion of the honeydew by the aphid.

Thus the concentration of the amino acids especially the acidic amino acids and amides coupled with the reduction in the turgor pressure of the host plant, as shown by the decrease in the frequecy of excretion of the aphid under the influence of water stress, appear to be important factors which reduce the fecundity of this aphid under such conditions.

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ON THE HYDROGEN-ION CONCENTRATION AND DISTRIBUTION OF DIGESTIVE ENZYMES IN THE MIDGUT OF *GONOCEPHALUM* SP. (TENEBRIONIDAE : COLEOPTERA)

S. C. GOEL & A. C. BHARDWAJ

Department of Zoology, Sanatan Dharm College, Muzaffarnagar, India 251 001

(Received 11 October 1981)

The hydrogen-ion concentration in the proximal part of the midgut of Gonocephalum sp. is relatively more acidic than the distal. The zonal distribution of various enzymes have been described. Starvation played no significant role on the hydrogen-ion concentration. However, it influenced the enzyme concentration in the midgut.

INTRODUCTION

Hydrogen-ion concentration and the digestive enzymes of tenebrionid larvae infesting stored grains and grain products were explored in past by several workers (FRENZEL, 1882; KRISHNA, 1958 a, b; APPLEBAUM *et al*, 1961; BHATNAGAR, 1962; KRISHNA & SAXENA, 1962; APPLEBAUM, 1964). DADD (1956) and BRIK *et al.* (1962) studied the proteolytic activity in the midgut of adult *Tenebrio* and *Tribolium* species respectively. In the absence of adequate information on the digestive secretions, the present study has been extended further to an adult *Gonocephalum* sp., a common pest of grapevine roots. A zonal distribution of these enzymes has also been attempted.

MATERIAL AND METHODS

Insects used in the present investigation were collected from a grapevine grove. With an emptied gut, both fed and starved individuals were rapidly vivisected under stereoscopic binocular microscope in double distilled cold water. Entire digestive tract cleared of extraneous tissues was taken out over plain glass, and processed further for present study.

pH Determination: Quickly vivisected in ice cold distilled water, the midgut was cut into three distinct parts viz., promesenteron, mesomesenteron and metamesenteron. The gut contents from these morphologically distinct parts of naturally fed and 24 hr starved individuals were collected in cavity blocks separately. A drop of gut content was then put over the narrow range pH indicator paper (B. D. H.), and then the pH estimated from the colour developod was noted for several replicates (Table 1).

Enzyme assay: Homogenate preparation: Five to ten similar parts were pooled and homogenised alongwith cold water in teflon pestle homogeniser. The homogenate was centrifuged for 10 to 15 minutes and placed into labelled vials. The supernatant after proper dilution (5 midguts ml) served as crude preparation for enzyme assay.

Reaction and control mixtures: For qualitative analysis of digestive enzymes the gut homogenate, the substrate and the corresponding buffer were mixed in 1:1:1 proportions. A drop of antibacterial agent, toluene, was added to the microtube containing the reaction mixture. Keeping in boiling water for ten minutes, the native enzyme extract got denatured and was also mixed with the substrate and the buffer to serve as the control. Both reaction and control mixtures were incubated at 37°C ± 2°C for 12 to 24 hr with occasional shaking.

Carbohydrases: After incubation, the hydrolysis of reducing substrate was determined by

Benedict's qualitative test for reducing sugar released (PLUMMER, 1971) whereas reducing substrate was analysed by thin layer chromatography (Table 2). The reaction and control mixtures along with reference sugars were spotted at 2 cm intervals on silica gel G coated on 29 × 20 cm glass plates. These chromatoplates were then run in *n*-butanol, acetic acid and water mixture (4:1:5) (V/V). Sugars were visualised with the spray of aniline-diphenylamine (PLUMMER, 1971) reagent. Hydrolysed products were also indentified with the help of reference spots. The intensity of spot indicated the magnitude of the enzymatic activity.

Proteases: 2% casein solution was used as substrate (BALDWIN & BELL, 1967). After incubation the reaction mixture was treated with 1% acetic acid. The absence of precipitates in this mixture confirmed the protease activity.

Polypeptidases: Substrate used was 2% peptone solution. After incubation dilute acetic acid and a few drops of bromine water were poured into the reaction mixture. The development of pink colour confirmed the polypeptidase activity (KRISHNA & SAXENA, 1962).

Esterases: A few drops of phenol red were added to the ethyl butyrate. It was then made alkaline with a few drops of 0.01N NaOH until the colour of the solution changed to pink before incubating it with the gut homogenate. A change in colour from pink to yellow in the incubated mixture indicated the esterase activity. Similarly activity of lipase was determined by using an olive oil emulsion as substrate (BALDWIN & BELL, 1967).

Urease: For the determination of urease FEIGL's (1958) technique was adopted.

RESULTS AND DISCUSSION

Under naturally fed condition the hydrogen-ion concentration of the digestive fluid in the proximal part of the midgut of *Gonocephalum* sp. was recorded to be faintly acidic (5.72 ± 0.034), which further decreased in acidity distally (5.92 ± 0.02) (Table 1). SINHA (1958) in *Tenebrio*, SRIVASTAVA & SRIVASTAVA (1961) in *T. molitor* and *Tribolium castaneum* established a pH range between 5.2 and 6.8 for the digestive secretions including sixteen species from different coleopteran families. KRISHNA & SAXENA (1962) supported the range while describing the larval tenebrionid gut. The present observation tallies with that of RAO & RASTOGI (1967), in that the weakly acidic nature of pH of midgut secretions thus approaches neutrality, a generalised condition for tenebrionid gut (WATERHOUSE, 1953). The variation in pH from proximal to distal lumen of the midgut in the present study, further, favoures the zonal differentiation in the midgut of tenebrionids described by WIGGLESWORTH (1953).

Starvation has no significant role over the hydrogen ion concentration in the present study (5.77 ± 0.01). It is perhaps due to the strong buffering capacity that the 'stomach reaction' in most of the insects remained unaffected by the type of food they consumed (WIGGLESWORTH, 1927; SWINGLE, 1931; DAY & POWNING 1949). CHAPMAN (1972) recently explained that the maintenance of buffering system in the midgut is due to the continuous secretion of organic acids, their salts and mono— or dihydrogen phosphates. No remarkable difference in the pH of fed and starved conditions of the midgut thus suggests for a continuous secretion of enzymes. KRISHNA (1958 a, b) and RAO & RASTOGI (1967) also arrived at similar conclusions in their respective tenebrionids studied.

In *Gonocephalum* sp., the midgut secretions showed the presence of α—amylase, α— and β—glucosidase, α—galactosidase and β—fructosidase as major carbohydrases whereas further analysis of reaction mixture detected β—galactosidase, α,α—trehalase and urease in traces (Table 3).

The amylase reported in different larval tenebrionids (KRISHNA, 1958 b;

TABLE 1. Hydrogen-ion concentration in different parts of the midgut of *Gonocephalum* sp.

Midgut parts	Fed	Starved
Promesenteron	5.72 ± 0.034	5.70 ± 0.108
Mesomesenteron	5.75 ± 0.024	5.69 ± 0.070
Metamesenteron	5.92 ± 0.002	5.94 ± 0.001
Average	5.79 ± 0.049	5.77 ± 0.007

TABLE 2. Qualitative estimation of different enzymes.

Enzymes	Substrate	Method of detection
Carbohydrases		
α—Amylase (3.2.1.1)	0.5% Solution of starch	Benedict's test
Cellulase (3.2.1.4.)	Corboxymethyl cellulose	Benedict's test
Inulase (3.2.1.7)	Inulin suspension aq.	Benedict's test
Chitinase (3.2.1.14)	Chitin suspension aq.	Dissolution
Polygalacturonase (3.2.1.15)	Pectin suspension aq.	Dissolution
α—Glucosidase (3.2.1.20)	2% Maltose solution	TLC & Barfoed test
β—Glucosidase (3.2.1.21)	2% Cellobiose solution	TLC
α—Galactosidase (3.2.1.22)	5% Raffinose solution	
	5% Melibiose solution	TLC
β—Galactosidase (3.2.1.23)	2% Lactose solution	TLC
β—Fructosidase (3.2.1.26)	Phenyl-B-fructoside	TLC
	5% Sucrose solution	TLC
	5% Raffinose solution	TLC
α,α—Trehalase (3.2.1.28)	2% Trehalose solution	TLC
Proteinases		
Protease-A (3.4.21.3)	1% Casein solution	1% Acetic acid
Polypeptidase	1% Peptone solution	Biuret test
Esterases		
Carboxylesterase (3.1.1.1)	Ethyl butyrate emulsion	Phenol red
Triacylglycerolipase (3.1.1.3)	Olive oil emulsion	Phenol red
Amidase		
Urease (3.5.1.5)	1% Urea solution	Feigl test

Enzymes Commission Number in parenthesis.

TABLE 3. Distribution of digestive enzymes in different conditions of midgut of *Gonocephalum* sp.

Enzymes	Relative activity*					
	Promesenteron		Mesomesenteron		Metamesenteron	
	Starved	Fed	Starved	Fed	Starved	Fed
Carbohydrases						
α-Amylase	++	+++	++	+++	++	++
Cellulase	–	–	–	–	–	–
Inulase	–	–	–	–	–	–
Chitinase	–	–	–	–	–	–
Polygalacturonase	–	–	–	–	–	–
α-Glucosidase	++	++	++	+++	++	++
β-Glucosidase	–	++	+	++	+	++
α-Galactosidase	–	+	++	+++	+	+
β-Galactosidase	–	–	–	t	+	t
β-Fructosidase	–	+	–	++	+	++
α, α-Trehalase	–	–	–	t	t	t
Proteinases						
Protease—A	–	–	–	++	–	+++
Polypeptidase	–	t	–	+++	+	+++
Esterases						
Carboxylesterase	–	+	–	+	–	++
Triacylglycerolipase	–	–	–	–	–	++
Amidase						
Urease	–	–	–	–	–	t

* Five replicales were used

+++ Brisk activity, ++ Moderate activity, + Feeble, –Absence, t Traces.

BHATNAGAR, 1962; KRISHNA & SAXENA, 1962; RAO & RASTOGI, 1967) was further differentiated into α— and —βamylase in the midgut of larval *Tenebrio* sp. by APPLEBAUM (1964). The presence of α—amylase, one of the starch hydrolysing carbohydrase, in adult *Gonocephalum* sp. is in conformity with GILMOUR (1961) for insects in general.

The presence of α—glucosidase (maltase and invertase) invariably reported in different groups of insects was also observed in *Gonocephalum* sp. Similar to *Latheticus oryzae* (BHATNAGAR, 1962) and *Tribolium castaneum* (KRISHNA & SAXENA, 1962) the β—glucosidase (cellobiase) was also described in the present tenebrionid.

The α—galactosidase in *Gonocephalum* sp. also actively digests substrates like raffinose and melibiose. Its existence was however, not reported in the larva of *L. oryzae* (BHATNAGAR, 1962). The β—galactosidase (lactase) available in the midgut of both the larva and adult of *T. castaneum* (KRISHNA & SAXENA, 1962) and in the larva of *L. oryzae* (BHATNAGAR, 1962)

was noticed with poor activity in the present study. Thus it can be concluded that α—β—galactosidase irrespective of their activity are available in Tenebrionidae. Brisk activity of β—fructosidase is an observation in conformity to the findings in *Dermestes maculatus* (CHENNERY, 1971), feeble to moderate activity in *Gonocephalum* sp. and *L. oryzae* (BHATNAGAR, 1962) is another common feature for Tenebrionidae.

The midgut of *Gonocephalum* sp. has further, protease—A, polypeptidase, carboxylesterase (esterase), triacylglycerolipase (lipase) and urease (Table 2). Similar observations have also been made by RAO & RASTOGI (1962) in *Arthroideis* sp BHATNAGAR (1962) however, remarked that the midgut of *L. oryzae* secrete protease and esterase only whereas KRISHNA & SAXENA (1962) further noted the presence of esterase in *T. castaneum*.

Most of the carbohydrases with varied digestibility were recorded in the midgut ie., the mesomesenteron (Table 2) although proteinases were secreted in moderate concentrations in the same region yet their activity probably got enhanced towards the metamesenteron. The esterases were also noticed in moderate activity in the distal part. The α—amylase is the only enzyme of the promesenteron with brisk activity. The zonal differentiation in *Gonocephalum* sp. for optimum activity of the carbohydrases is the mesomesenteron. A decrease in the hydrogen-ion concentration towards neutrality perhaps supported the activity of the proteinases and esterases distally. The α—amylase which digests starch in the promesenteron comparatively in an acidic pH is the only exception.

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STUDIES ON THE USE OF NYMPHS FOR RAPID SCREENING OF COTTON GERM-PLASM FOR RESISTANCE TO JASSID

G. S. MAVI & A. S. SIDHU

Department of Entomology, Punjab Agricultural University, Ludhiana, India 313001

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Studies were taken up to determine the suitable nymphal instar and optimum population level for rapid screening of cotton germ-plasm for resistance to jassid. Five nymphal instars were tested each at three levels of population i. e., first & second instars at 5, 10, 15; third and fourth instars at 3, 5, 10 and fifth instar at 2, 5 and 8 nymphs per seedling. Injury symptoms produced on a highly susceptible variety *PS 10* and a relatively tolerant variety *J 34* were observed and grouped into four grades. Since significant differences in the appearance of fourth grade injury symptoms were discernible between the susceptible and resistant varieties within 4.0 days, use of 10 third-instar nymphs per seedling was found to be suitable for rapid screening of cotton germ-plasm.

(*Key words*: nymphal instar, optimum population, screening cotton germ plasm)

INTRODUCTION

The cotton jassid (*Amrasca devastans* ISHIDA) is a serious pest of the American cotton (*Gossipium hirsutum* L.) in India. A number of insecticides are effective against this pest but they are rather expensive and their large scale use may lead to disturbance of natural balance resulting in a number of secondary problems (SMITH, 1970). Accordingly, the use of resistant varieties as a component of pest management appears highly desirable because it is compatible with other methods of control. In screening for jassid resistance, the following techniques have been adopted: (i) morphological plant characters associated with resistance; (ii) analysis of plants for certain chemicals; (iii) build-up of jassid population and (iv) extent of damage. Main morphological characters used for these studies are the hair length, hair density and angle of their insertion. Such studies have shown that though hairiness is associated with resistance it is not infallible guide for screening varieties (HUSSAIN, 1937; BALASUBRAMANYAN & IYENGAR, 1950; ANNAPAN, 1960). No definite relationship has been established between jassid resistance and the qualitative/quantitative presence of certain chemicals in the cotton plants (SINGH *et al.*, 1972; KRISHNANANDA, 1972). The techniques at (iii) and (iv) above are based on the build-up of the jassid population and the damage caused by it. These seem to be reliable but are rather time-consuming. Therefore, by using these techniques only a limited number of varieties can be tested in a given time. This problem in some crops like rice, maize, sorghum, wheat and cucurbits, has been solved successfully by subjecting seedlings to the known levels of pest population. Such a technique has also been adopted in cotton for screening against mites (SCHUSTER *et al.*, 1972). The present studies were, therefore, taken up to find out the suitable

nymphal instar and its population for screening cotton germ plasm at the seedling stage.

MATERIALS AND METHODS

These studies were conducted in screen-house at the Entomology Research Farm of Punjab Agricultural University, Ludhiana. The screenhouse (305 × 213 × 183 cm) was fitted with galvanised iron-wire netting (30 meshes/2.5 cm) and was insect-proof as far as jassid was concerned. Two varieties of *hirsutum* cotton viz., *PS 10* and *J 34* were used in these studies. The *PS 10* is highly susceptible whereas *J 34* is relatively tolerant to jassid attack. The cotton seedlings were raised in earthen pots. The sowing was done on different dates to get a continuous supply of the seedlings for different experiments.

The first and second instar nymphs were collected from the infested leaves of okra plants. They were picked up individually using a fine camel-hair brush and released directly on the potted seedlings which were later on covered with glass railway globes. The jassid nymphs of third, fourth and fifth instars were collected with the help of a tube aspirator.

All the five nymphal instars were tested at 3 population levels (indicated in Table 1) to find out the most efficient instar and the optimum population which could cause the clearly discernible damage symptoms. Ten seedling plants were used for each population level. They were examined daily for damage symptoms which were graded as below. Grade I—healthy, all leaves free from jassid injury; Grade II—all leaves withered and wrinkled, growth retarted; Grade III—all leaves curled downwards resulting in cupping; and Grade IV—all leaves turned brown, dried and dropped-off resulting in death of the plants.

RESULTS AND DISCUSSION

Time taken for the appearance of injury symptoms by different population levels of various nymphal instars is indicated in Table 1. It was found that excepting two cases in all other cases differences were significant between two varieties where injury symptoms of a given grade appeared earlier in the highly susceptible variety (*PS 10*) than in the relatively tolerant variety (*J 34*). In general higher population of a given nymphal instar produced the specific injury grade symptoms in a shorter time and at the same level of population longer time was required for the appearance of higher grade injury symptoms.

Suitable nymphal instar: In the experiments described in Table 1 population level of 5 nymphs was common for all five instars and that of 10 nymphs per seedling for the first four instars. In order to determine the most suitable instar, data in respect of these two population levels was pooled and analysed separately (Table 2). It is apparent from this analysis that the third instar was always significantly better than the first and the fifth instars in producing injury symptoms of different grades. However, at $p = 0.01$ level the third instar was as good as the fourth instar in producing injury symptoms of the second grade at both the population levels and of the fourth grade at 10 nymphs per seedling. When these two instars were compared at $p=0.05$ level, the third instar was significantly better than the fourth instar in producing symptoms of all the three injury grades at both the population levels. There was no significant difference at $p=0.01$ between the second and third instars in producing symptoms of all the three grades at both the levels of population. Even at $p=0.05$ level, there was no significant difference between these two instars in producing symptoms of the second grade at both the levels of population and causing fourth-grade injury symptoms at the population level of 5 nymphs per seedling. However, handling of the second-instar nymphs was rather difficult because they could not be sucked easily into the aspirator. Moreover, when released under the railway globe with the help of the aspirator, may second-instar

TABLE 1. Time (days) taken for the appearance of jassid injury symptom grades on seedlings of *PS 10* and *J 34* with different population levels of various nymphal instars.

Nymphal instar	Nymphal population per seedling	Second grade injury symptoms			Third grade injury symptoms			Fourth grade injury symptoms		
		PS 10	*J 34*	Mean	*PS 10*	*J 34*	Mean	*PS 10*	*J 34*	Mean
I	5	4.6	4.9	4.75	5.7	6.0	5.85	7.0	7.4	7.20
	10	3.3	4.3	3.80	4.2	5.3	4.75	5.3	5.9	5.60
	15	2.9	3.2	3.05	3.7	4.2	3.95	4.6	5.0	4.80
	Mean	3.60	4.13	3.87	4.53	5.17	4.85	5.63	6.10	5.87
C.D. for population (p = 0.1)				0.46			0.68			0.65
C.D. for varieties (p = 0.01)				0.37			0.56			NS
II	5	1.4	1.7	1.55	3.0	3.7	3.35	4.2	5.1	4.65
	10	1.0	2.1	1.55	2.2	3.3	2.75	3.7	5.1	4.40
	15	1.4	1.7	1.55	2.5	2.7	2.60	3.4	4.0	3.70
	Mean	1.27	1.83	1.55	2.57	3.23	2.90	3.77	4.73	4.25
C.D. for population (p = 0.01)				NS			0.62			0.75
C.D. for varieties (p = 0.01)				0.33			0.50			0.61
III	3	3.3	6.2	4.75	7.9	10.5	9.20	11.2	13.1	12.15
	5	1.0	2.0	1.50	2.2	3.0	2.60	4.3	4.2	4.15
	10	1.0	1.6	1.30	2.0	2.8	2.40	3.0	4.0	3.60
	Mean	1.77	3.27	2.52	4.03	5.43	4.73	6.17	7.10	6.63
C.D. for population (p = 0.01)				0.65			0.65			1.08
C.D. for varieties (p = 0.01)				0.53			0.54			0.88
IV	3	6.0	7.0	6.50	8.3	9.3	8.80	10.5	12.6	11.55
	5	1.6	2.3	1.95	2.8	4.7	3.75	6.4	11.7	9.05
	10	1.2	2.2	1.70	2.2	3.7	2.95	3.2	5.3	4.25
	Mean	2.93	3.83	3.38	4.43	5.90	5.17	6.70	9.87	8.28
C.D. for population (p = 0.01)				0.93			1.02			2.04
C.D. for varieties (p = 0.01)				0.76			0.83			1.67
V	2	3.2	4.0	3.60	5.8	5.7	5.75	10.0	—	—
	5	2.6	3.6	3.10	4.0	5.0	4.50	9.6	9.8	9.70
	8	1.8	1.8	1.80	3.0	3.3	3.15	5.5	7.4	6.45
	Mean	2.53	3.13	2.83	4.27	4.67	4.47	7.55	8.60	8.08
C.D. for population (p = 0.01)				0.75			0.87			1.24
C.D. for varieties (p = 0.01)				0.45			NS			0.93

TABLE 2. Time (days) taken for the appearance of jassid injury symptom grades on varieties *PS 10* and *J 34* with 5 and 10 nymphs of different instars per seedling.

Nymphal popula-level per seedling	Nymphal instar	Second grade injury symptoms			Third grade injury symptoms			Fourth grade injury symptoms		
		PS 10	*J 34*	Mean	*PS 10*	*J 34*	Mean	*PS 10*	*J 34*	Mean
5	I	4.6	4.9	4.75	5.7	6.0	5.85	7.0	7.4	7.20
	II	1.4	1.7	1.55	3.0	3.7	3.35	4.2	5.1	4.65
	III	1.0	2.0	1.50	2.2	3.0	2.60	4.3	4.2	4.15
	IV	1.6	2.3	1.95	2.8	4.7	3.75	6.4	11.7	9.05
	V	2.5	3.6	3.10	4.0	5.0	4.50	9.6	9.8	9.70
C.D. for instars (p=0.01)				0.55			0.94			1.24
(p=0.05)				0.42			0.71			0.94
10	I	3.3	4.3	3.80	4.2	5.4	4.80	5.3	6 0	5.65
	II	1.0	2.1	1.55	2.2	3.3	2.75	3.7	5.1	4.40
	III	1.0	1.6	1.30	2.0	2.8	2.40	3.0	4.2	3.60
	IV	1.2	2.2	1.70	2.2	3.7	2.95	3.2	5.3	4.25
C.D. for instars (p=0.01)				0.47			0.41			0.83
(p=0.05)				0.35			0.31			0.62

nymphs fell at the bottom of the potted plants; they failed to climb up the plants and perished. They had to be picked up and released individually on the leaves with the help of a fine camel hair brush. This makes their use rather laborious. Therefore, even though second-instar nymphs were as effective as the third-instar nymphs they cannot be used for large-scale screening due to difficulty in handling them. These practical considerations lead to the conclusion that third instar is the best for use in the screening programmes.

Suitable injury grade symptoms: Overall mean time taken for the appearance of II, III and IV grade injury symptoms for different levels of the population of third instar nymphs was 2.52, 4.73 and 6.63 days respectively. Even though appearance of IV grade injury symptoms took longer time, screening based on the adoption of this grade would be more reliable because it would show the cumulative effect of II and III grades also. In addition all the seedlings showing IV grade injury symptoms invariably died. Grading is essentially a work of subjective nature and there are lesser chances of mistake if death of seedlings is adopted as a criterion of screening.

Optium population of nymphs: Examination of the data regarding the time taken for the appearance of IV grade injury symptoms by third instar nymphs given in Table 1, would show that there was no significant difference between two varieties at population level of 5 nymphs per seedling. But such differences were significant in two varieties at population level of 3 and 10 nymphs. However, fourth grade injury symptoms appeared in 3.0 and 4.0 days in case of 10 nymphs as compared with 11.2 and 13.1 days in case of 3 naymphs in *PS 10* and *J 34* respectively. It, therefore, seems desirable to use a population level of 10 nymphs

of the third instar for screening cotton germ plasm at the seedling stage based on the appearance of IV grade injury symptoms.

Since significant differences in the appearance of IV grade injury symptoms are discernible between the susceptible and resistant varieties within 4.0 days, use of 10 third instar nymphs per seedling will help in rapid screening of cotton germ plasm. This appears to be the first attempt at comparing the suitability of various nymphal instars at different population levels to produce a given injury grade in susceptible and resistant varieties of cotton.

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CROSS-RESISTANCE CHARACTERISTICS OF LINDANE RESISTANT AND SUSCEPTIBLE STRAINS OF *TRIBOLIUM CASTANEUM* (HERBST) (COL : TENEBRIONIDAE)

B. N. BARWAL[1] & R. L. KALRA

Department of Entomology, Punjab Agricultural University, Ludhiana, India

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A highly lindane resistant and two susceptible strains of indigenous and exotic origin of *Tribolium castaneum*, were employed to study the cross-resistance characteristics of different groups of insecticides. Lindane resistance extended to dieldrin, endrin, heptachlor, aldrin and endosulfan in the cyclodiene group of insecticides. All the three strains remained equally susceptible to p, p'-DDT and methoxychlor group, allethrin in the pyrethroids group and malathion, fenitrothion and dichlorovos in the organophos group of insecticides. In case of carbamate group of insecticides, lindane resistance extended to carbaryl and carbofuran but not to propoxur. Juvenile hormone, R-20458 was found to be equally effective on all the three strains.

(*Key words:* resistance, strain, insecticide, juvenile hormone, LD_{50}, ED_{50}, bioassay)

INTRODUCTION

Resistance to lindane in red flour beetle *Tribolium castaneum* has been detected in various parts of the world, including India (DYTE & BLACKMAN, 1970; KALRA *et al.*, 1975, CHAMP & DYTE, 1977). In general, lindane resistance in insects extends to cyclodiene group of insecticides (BROWN & PAL, 1971). However, KALRA & JOSHI (1974) suggested that lindane and dieldrin resistance was not a single entity. Further, there is sufficient evidence that lindane resistance does not extend to carbamate insecticides. However, BHATIA & PRADHAN (1972) found lindane resistant strain of *T. castaneum* showing tolerance to carbaryl. Studies were, therefore, undertaken on cross-resistance characteristics of resistant and susceptible strains of *T. castaneum* in order to understand the nature of the mechanism of resistance.

[1] Present address:—ICAR Research Complex for NEH Region, Manipur Centre, Imphal, India.

MATERIAL AND METHODS

Insects:

Populations of *Tribolium castaneum*, originally collected from different places in Punjab (India), were pooled together. They were allowed to multiply to have composite culture (KALRA *et al.*, 1975). A set of the succeeding generations of such culture was selected in the laboratory by exposing the adults to filter papers impregnated with lindane. Adults of this culture were found to tolerate as high as 16.0 per cent concentration of lindane (hereafter referred to as lindane-resistant strain or strain-*R*). Lindane susceptible strains were obtained from two different sources. Palampur strain or strain-*P* was collected from a remote place in Himachal Pradesh (India), where grain protectants are not in use. Slough strain or strain—*S* was obtained from the Pest Infestation Control Laboratory, Slough, Berks (U. K.) as a standard susceptible strain.

Insect cultures of different susceptible and resistant strains were raised in jars on wheat flour (*Kalyan-227*), containing 5 per cent yeast. At the end of every month, the freshly emerged adults were provided with the fresh food. Each generation of the lindane resistant strain was selected by exposing the adult insects to filter

papers impregnated with lindane, following the method recommended by the FAO, 1970. Maintenance and testing of cultures was done at 31±1°C.

Insecticides:

The following insecticides were used: lindane, dieldrin, aldrin, endrin, heptachlor, endosulfan, p, p'—DDT, Methoxychlor, allethrin, malathion, fenitrothion, dichlorovos, carbaryl, carbofuran and propoxur. Juvenile hormone, R-20458 was also tested against lindane resistant and susceptible strains.

Bioassay:

Graded concentrations of the insecticides solution in acetone were applied topically at the rate of 1 microlitre per insect with the help of a microsyringe. The treated insects were kept in petri dishes at 31±1°C for 24 hours after which the mortality in them was recorded. The data obtained were subjected to probit analysis (FINNEY, 1952).

Synthetic hormone was tested against the larval stage of *T. castaneum*. Final instar larvae of the same age and size were selected from the standard cultures of different strains. They were treated topically on the abdominal part, with 0.5 microlitre of graded concentrations of the hormone solution in acetone, with the help of a microsyringe. The larvae were then transferred to the wheat flour in the petri dishes. Their failure to emerge as healthy adults during 2 weeks period was taken as a criterion of response.

RESULTS

Susceptibility to insecticides:

Resistance pattern of lindane resistant and susceptible strains of *Tribolium castaneum* to different groups of insecticides is given in Table 1. The degree of lindane resistance in comparison with known susceptible strain-*S* was found to be 3.24 and 180.64 for strain-*P* and strain-*R* respectively. Resistance to dieldrin, endrin, heptachlor, aldrin and endosulfan was found in decreasing order in strain-*R*. Strain-*P* was found to have low level of tolerance to all the cyclodiene insecticides, but was more susceptible than stain-*S* for endosulfan. The degree of resistance to dieldrin was 9.3 and 128.8, and to endosulfan 0.5 and 4.4 in strain-*P* and strain-*R* respectively.

In comparison to strain-*S*, both the strains had slight tolerance to p, p'-DDT but were more susceptible to methoxychlor. Strain-*R* was slightly tolerant to allethrin as compared to strain-*P* and strain-*S*. Among the organophos group of insecticides, a tolerance of 3.9 times to malathion only was found in strain-*R*. However, strain-*P* was as susceptible as strain-*S* to malathion, fenitrothion and dichlorovos.

The levels or resistance of strain-*P* and strain-*R* were found respectively to be 0.65 and 16.60 for carbaryl, 1.86 and 13.49 for carbofuran and 0.28 and 2.70 for propoxur. Thus lindane resistance extended to carbaryl and carbofuran and not to propoxur. As compared to strain-*S*, strain-*P* had more suscsptibility to carbaryl and propoxur, but to carbofuran.

All the three strains were found susceptible to synthetic juvenile hormone, R-20458 (Table 1). The ED_{50} of this hormone was found to be minimum, i. e., 0.050 μg/insect during larval adult transformation of strain-*R*. The levels of resistance of strain-*P* and strain-*R* were found to be 2.34 and 0.64 respectively in comparision to strain-*S*.

DISCUSSION

Lindane resistance in strain-*R* of *Tribolium castaneum* extended to cyclodiene group of insecticides. This is typical of the pattern found in many insect species (BUSVINE, 1967; BROWN & PAL, 1971). On the other hand, there is evidence for the presence of certain exclusive mechanism of resistance for lindane which is not shared by dieldrin (BRUCE & DECKER,

TABLE 1. Resistance pattern of lindane resistant and susceptible strains of *Tribolium castaneum*.

Insecticide	Slough strain—*S*		Palampur strain—*P*			Resistant strain—*R*		
	I D_{50} (Fiducial limits)	Slope ±S.E.	LD_{50} (Fiducial limits)	Slope ±S.E.	R.R.	LD_{05} (Fiducial limits)	Slope ±S.E.	R.R.
Lindane	0.069 (0.035 −0.138)	1.0 ±0.3	0.224 (0.151 −0.331)	1.8 ±0.3	3.2	>12.5	—	>180.6
Dieldrin	0.00115 (0.00004−0.004)	1.45 ±0.6	0.0107 (0.0065−0.0178)	1.3 ±0.3	9.3	0.148 (0.115 − 0.191)	2.2 ±0.5	128.8
Aldrin	0.081 (0.04 −0.166)	1.2 ±0.4	0.120 (0.091 −0.158)	2.2 ±0.4	1.5	1.202 (0.813 − 1.778)	1.6 ±0.3	14.8
Endrin	0.293 (0.234 −0.375)	2.7 ±0.5	0.339 (0.275 −0.417)	2.8 ±0.4	1.15	7.943 (2.754 −22.909)	1.2 ±0.4	26.9
Heptachlor	0.741 (0.468 −1.75)	1.4 ±0.3	1.995 (1.514 −2.63)	2.1 ±0.35	2.7	14.791 (9.55 −22.909)	1.5 ±0.3	19 95
Endosulfan	2.818 (1.48 −6.918)	0.7 ±0.15	1.318 (0.794 −2.188)	1.2 ±0.2	0.5	>12.5	—	>4.4
P,P'—DDT	0.182 (0.135 −0.245)	2.0 ±0.35	0.355 (0.257 −0.49)	1.8 ±0.3	1.95	0.447 (0.347 − 0.575)	2.6 ±0.4	2.45
Methoxychlor	1.479 (0.977 −2.239)	1.7 ±0.3	1.202 (0.813 −1.778)	1.8 ±0.3	0.8	1.413 (0.692 − 2.884)	0.9 ±0.2	0.95
Allethrin	0.331 (0.263 −0.417)	2.5 ±0.4	0.331 (0.275 −0.39)	3.3 ±0.5	1.0	0.661 (0.537 − 0.813)	3.2 ±0.7	2.0
Malathion	0.01 (0.0083 −0.012)	3.4 ±0.7	0.01 (0.0054−0.0195)	3.1 ±0.5	1.0	0.039 (0.03 − 0.05)	2.8 ±0.4	3.9
Fenitrothion	0.0043 (0.0035 −0.0052)	3.55 ±0.7	0.0042 (0.0034−0.0051)	3.55 ±0.7	1.0	0.0047 (0.0038− 0.0058)	3.5 ±0.7	1.1
Dichlorovos	0.0224 (0.0204 −0.0245)	3.6 ±0.6	0.0204 (0.0174−0.024)	3.6 ±0.6	0.9	0.0251 (0.0209− 0.0302)	3.15 ±0.6	1.1
Carbaryl	0.288 (0.141 −0.589)	0.9 ±0.25	0.186 (0.081 −0.427)	0.85 ±0.25	0.65	4.786 (2.344 − 9.772)	0.75 ±0.1	16.6
Carbofuran	0.0066 (0.0049 −0.089)	2.5 ±0.6	0.0123 (0.0091−0.0166)	2.1 ±0.4	1.9	0.089 (0.0417− 0.1906)	0.8 ±0.2	13.5
Propoxur	3.222 (1.0 −6.233)	1.3 ±0.3	0.912 (0.045 −1.862)	1.0 ±0.3	0.3	8.710 (1.862 −40.738)	1.1 ±0.3	2.7
R—20458*	0.078 (0.058 −0.092)	1.7 ±0.44	0.182 (0.065 −0.513)	1.6 ±0.7	2.3	0.050 (0.031 ± 0.081)	2.1 ±0.5	0.6

LD_{50} is the dose which kills 50 per cent of the insect population and is expressed as μ g/insect; Fiducial limits of LD_{50} are expressed at P = 0.05 level; R. R. Means 'Resistance Ratio'. *Juvenile hormone, the median dose of which (ED_{50}) affects 50 per cent of the population.

1950; BUSVINE & TOWNSEND, 1963; OPPENOORTH & NASARAT, 1966; & KALRA & JOSHI, 1974). Within the group, the degree of resistance to dieldrin in strain-*R* of *T. castaneum* was found to be maximum. The cross-resistance to endosulfan was found to be the least, both during the present investigations and also by BHATIA & PRADHAN, (1972). Similarly, BUSVINE (1954) reported different cross-resistance spectra within the cyclodiene insecticides in the case of housefly, *Musca domestica*. This, therefore, indicates that the degree of cross-resistance to different insecticides in a particular group is likely to vary in species.

In general, lindane resistance in insects does not extend to pyrethrin-allethrin, DDT-methoxychlor and organophosphorus groups of insecticides (BROWN & PAL, 1971). BHATIA & PRADHAN (1972), also reported similar results in the case of lindane selected strain of *T. castaneum*. Lindane resistance in the present investigations also, did not extend to p, p'-DDT, methoxychlor, allethrin, and organophosphorus insecticides.

Lindane resistance in *T. castaneum* did not extend to synthetic juvenile hormone, R-20458. DYTE (1972), however, reported tolerance to a natural juvenile hormone (cecropia JH) in a strain of *T. castaneum* resistant to DDT, organophosphates, carbamates, but not to lindane and cyclodiene group of insecticides. Similarly, evidence of cross-resistance to juvenile hormone mimic ENT-70460 in strains of insecticide resistant housefly is provided by CERF & GEORGHIOU (1972) and PLAPP and VINSON (1973).

Insects, resistant to lindane and cyclodiene group of insecticides were found susceptible to carbamates (BUSVINE, 1967; BROWN & PAL, 1971). However, BHATIA & PRADHAN (1972) reported 12-fold cross-resistance to carbaryl in the lindane selected strain of *T. castaneum*. Similarly, in the present invesigations, lindane resistance in the laboratory selected strain-*R* of *T. castaneum* extended to carbaryl and carbofuran, but to propoxur. MOORFIELD (1960) and GEORGHIOU *et al.* (1961), however, found that strains of insects selected with one carbamate showed a degree of cross-tolerance to other carbamates. The results, therefore, indicate some linkage between lindane and carbamate resistance.

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CHEMICAL CONTROL OF INSECT PEST COMPLEX OF BRINJAL[1]

G. V. SUBBARATNAM[2] & DHAMO K. BUTANI[3]

[2]Pesticide Residue Laboratory, College of Agriculture, Rajendranagar, Hyderabad-500 030
[3]Divison of Entomology, I. A. R. I. New Delhi-110 012

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Two field experiments were conducted to study the comparative efficacy of fenitrothion, phenthoate and quinalphos each at 0.05 and 0.1 per cent and fenvalerate at 0.02 and 0.04 per cent against the important insect pests of brinjal. Two sprayings were given at monthly interval and the population of jassid, aphid and whitefly was recorded as also damage caused by the fruit borer. Results showed that fenvalerate at 0.04 and 0.02 per cent was superior over other insecticides followed by quinalphos 0.1 per cent, phenthoate 0.1 per cent and fenitrothion 0.1 per cent against all the four pests. The latter three insecticides were significantly superior at 0.1 per cent concentration over 0.05 per cent. Thus it is recommended to give two monthly sprayings with fenvalerate 0.02 per cent to effectively check the insect pest complex of brinjal.

(*Key words:* chemical control, insect pest complex, brinjal)

INTRODUCTION

Brinjal or egg plant, *Solanum melongena* LINNAEUS is native to India and is grown extensively in all the south-east Asian countries as also in south-east Europe (LOVELOCK, 1972). It is vulnerable to the attack by a number of insect pests, those of major importance include, shoot and fruit borer (*Leucinodes orbonalis* GUENEE), jassid (*Amrasca biguttula biguttula* ISHIDA), aphid (*Aphis gossypi* GLOVER) and whitefly (*Bemisia tabaci* GENNADIUS).

To control these insect pests, plant derivatives like, pyrenthrins and tobacco decoction were used in earlier days. With the invention of synthetic organic insecticides, BHC, DDT, endrin and parathion were used for effective control of brinjal pests. Subsequently organophosphates like, dimethoate, monocrotophos, phosphamidon etc. as also carbamates (carbaryl) are being recommended. However, side effects of some of these pesticides, namely, BHC imparting off flavour to brinjal fruits; endrin and parathion having very high mammalian toxicity; application of carbaryl resulting in secondary infestation of mites, limited the choice of insecticides. Besides, good many newer insecticides have since been marketed including synthetic pyrethroids. Therefore, studies were undertaken to test the efficacy of some newer insecticides including a pyrethroid in controlling the insect pest complex of brinjal.

MATERIAL AND METHODS

Two field experiments were conducted during rainy and autumn-winter seasons of 1978 at the Indian Agricultural Research Institute farm, New Delhi. The experiments were laid in simple randomised block design with nine treatments each replicated three times. The size of an individual sub-plot was 4.2 × 2.8 m. The spacing

[1] Part of the thesis submitted to P. G. School, I. A. R. I., New Delhi for the award of Ph.D.

within and in between the rows was 60 and 70 cm respectively. There were 28 plants in each sub-plot. The most common variety of brinjal grown around Delhi namely *pusa purple long* was raised as test variety. The insecticides tested were fenitrothion, phenthoate and quinalphos, each at 0.05 and 0.1 per cent and fenvalerate at 0.02 and 0.04 per cent. The first spraying was given soon after first appearance of jassids and whiteflies which coincided with the initiation of fruits. The second spraying was given a month after first spraying. The quantities of spray used were 1100 and 1200 litres per hectare for first and second sprayings respectively. The population data on jassid, aphid and whitefly were recorded from five leaves (two top, two middle and one bottom) from each of the ten central plants. Pre-treatment count was taken one day before spraying whereas the post-treatment data were recorded on 1st, 4th, 9th, 16th, 23rd and 30th day of spraying. Fruits were harvested at an interval of 7–10 days. At each harvest, the damaged and healthy fruits of each sub-plot were sorted out, counted and weighed to assess the damage by fruit borer.

RESULTS AND DISCUSSION

Fruit borer: The pooled data on the damage by fruit borer recorded in both the seasons (Table 1) indicate that all the insecticides had significantly less fruit damage as compared to control. The damage assessed on the basis of number of fruits and weight of fruits did not differ

TABLE 1. Comparative efficacy of various insecticides against fruit borer and jassid

Insecticide	Concentration (%)	Percentage of damaged fruits			Percentage reduction of jassid population		
		Rainy season crop	Autumn-winter crop	Mean	Rainy season crop	Autumn-winter crop	Mean
Fenitrothion	0.05	21.95 (27.89)	12.41 (20.36)	17.58 (23.19)	54.37 (47.53)	61.20 (51.49)	58.53 (49.92)
Fenitrothion	0.10	15.15 (22.82)	10.82 (19.09)	12.00 (20.21)	59.97 (50.79)	71.79 (57.98)	66.67 (54.75)
Phenthoate	0.05	17.50 (24.73)	13.55 (21.43)	14.68 (22.54)	50.81 (45.46)	54.33 (47.49)	52.85 (46.65)
Phenthoate	0.10	15.76 (23.38)	10.30 (17.78)	11.40 (19.67)	66.97 (54.94)	72.16 (58.21)	69.74 (56.68)
Quinalphos	0.05	16.62 (24.08)	9.97 (18.37)	11.87 (20.12)	55.83 (47.21)	65.88 (54.39)	61.02 (51.44)
Quinalphos	0.10	9.83 (18.24)	5.63 (13.65)	6.65 (14.89)	71.64 (57.84)	78.48 (62.60)	74.48 (59.71)
Fenvalerate	0.02	7.64 (15.97)	4.47 (12.07)	5.50 (13.53)	74.46 (60.36)	84.87 (67.20)	80.59 (63.87)
Fenvalerate	0.04	5.74 (13.63)	3.55 (10.66)	4.00 (11.33)	82.21 (65.06)	88.49 (70.27)	86.06 (68.12)
Control		56.34 (48.64)	26.27 (30.79)	36.29 (37.01)	7.60 (15.59)	17.21 (24.79)	13.53 (21.56)
S.Em ±		1.51	1.72	1.33	3.57	2.92	2.07
C.D. at 5%		3.20	3.65	2.82	7.57	6.19	4.39
C.D. at 1%		4.41	3.88	3.88	10.43	8.53	6.05

Figures in parentheses are arc sin $\sqrt{\text{percentage}}$.

significantly. Fenvalerate at both the concentrations was superior to other insecticides. However, quinalphos 0.1 per cent was at par with fenvalerate 0.02 per cent. Effective control of fruit borer with quinalphos was reported by VEERAVEL & BASKARAN (1977) and MOHE (1978). The other promising treatments were phenthoate 0.1 per cent, quinalphos 0.05 per cent and fenitrothion 0.1 per cent. Satisfactory control of the pest with phenthoate and fenitrothion observed in the present investigations is in agreement with the findings of GOWDA *et al.* (1977) and KRISHNAIAH *et al.* (1976) respectively. Phenthoate and fenitrothion at 0.05 per cent were comparatively less effective but significantly superior over control.

The fruit borer incidence was low in autumn-winter crop as compared to rainy season crop which could be attributed to low temperature (25.6 to 14.8°C) and relative humidity (57 to 70 per cent) that prevailed during the period of fruit bearing. The assumption is also supported by ATWAL & VERMA (1972) who reported that 30°C temperature and 70 to 90 per cent relative humidity are favourable for the development and survival of various stages of the insect and hence for its multiplication.

Jassid: The pooled data of two seasons (Table 1) indicate that all the insecticidal treatments were significantly superior to control in reducing the jassid population. Fenvalerate at both 0.02 and 0.04 per cent was superior to other treatments. Quinalphos 0.1 per cent was also highly effective and at par with fenvalerate 0.02 per cent. Phenthoate and fenitrothion at 0.1 per cent were also highly effective treatments followed by quinalphos

TABLE 2. Relative efficacy of various insecticides against aphid and whitefly.

Insecticide	Concentration (%)	Percentage reduction/increase in aphid population Autumn-Winter crop	Percentage reduction in whitefly population Rainy season crop	Autumn-winter crop	Mean
Fenitrothion	0.05	51.11(45.65)	45.57(42.43)	57.75(49.50)	51.34(45.82)
Fenitrothion	0.10	61.31(51.69)	53.67(47.12)	67.63(55.34)	59.89(50.72)
Phenthoate	0.05	48.30(43.91)	39.80(39.09)	53.45(47.00)	46.89(43.20)
Phenthoate	0.10	60.70(51.28)	54.46(47.54)	70.50(57.20)	62.26(52.11)
Quinalphos	0.05	50.68(45.41)	49.00(44.43)	56.74(48.88)	52.55(46.47)
Quinalphos	0.10	63.97(53.15)	59.71(50.62)	65.05(53.92)	62.61(52.35)
Fenvalerate	0.02	69.48(56.53)	67.76(55.41)	77.01(61.42)	72.17(58.17)
Fenvalerate	0.04	76.16(60.87)	72.22(58.26)	79.13(62.94)	75.74(60.60)
Control		*15.15(0.00)	13.66(21.64)	24.02(29.33)	17.75(23.90)
S.Em ±		3.36	1.99	2.42	1.73
C.D. at 5%		7.12	4.22	5.13	3.67
C.D. at 1%		9.81	5.81	7.07	5.05

Figures in parentheses are arc sin $\sqrt{\text{percentage}}$. * increase

and fenitrothion at 0.05 per cent. The least effective treatment was phenthoate 0.05 per cent, but even this was superior to control.

Aphid: The infestation of aphid was noticed only in autumn-winter crop. The data (Table 2) show that fenvalerate at both the concentratians was superior to other insecticides in reducing aphid population. However, quinalphos, fenitrothion and phenthoate at 0.1 per cent were as effective as fenvalerate 0.02 per cent. At lower concentration of 0.05 per cent, these three insecticides were comparatively less effective but gave about 50 per cent reduction in population as against 15.15 per cent increase of population in control. Satisfactory control of the aphid on cotton was reported by SINGH & VIJAY (1975) with fenitrtohion @ 0.5 to 0.8 kg a.i/ha.

Whitefly: The data recorded during two seasons on the effect of insecticides on whitefly population has been summarised in Table 2. It reveals that all the insecticides were significantly superior over control in checking the whitefly population. Fenvalerate at both the concentrations was superior to all other treatments. Quinalphos, phenthoate and fenitrothion at 0.1 per cent were found to be equally effective against the pest and were significantly superior to lower concentration of 0.05 per cent of the respective insecticides.

Slightly higher reduction in jassid as well as whitefly population was recorded in all the insecticidal treatments in autumn-winter crop as compared to rainy season crop. This might be due to the fact that temperature prevailing during the period of jassid and whitely incidence in autumn-winter season (25.6 to 14.8°C) was lower than during rainy season (32.5 to 29.2°C). Besides, some quantity of insecticidal deposit may have been washed off by the rains during rainy season.

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ECOLOGICAL STUDIES ON WHITEFLY, *BEMISIA TABACI* (GENN.) INFESTING CASSAVA IN KERALA

S. S. LAL[1] & K. S. PILLAI

Central Tuber Crops Research Institute, Trivandrum 695 017

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A study was undertaken at Trivandrum during 1975—76 through 1977—78 to find out the influence of weather factors viz., maximum and minimum temperatures, humidity and rainfall on the population of aleyrodid, *Bemisia tabaci* (Genn.) on cassava. The three years data indicated that the aleyrodid population was present throughout the year with peak infestation in January, March and June. The increase in population of *B. tabaci* was found to be significantly correlated with increase in maximum temperature during 1975—76 and 1977—78 and was found negatively correlated with rainfall during 1976—77.

(*Key words:* ecological studies, whitefly, *Bemisia tabaci*, Cassava)

INTRODUCTION

The whitefly, *Bemisia tabaci* (GENN.) is a potent vector of cassava mosaic disease in Asia and Africa which causes yield loss from 20 to 90 percent (LOZANO & BOOTH, 1974). Cassava mosaic is the most serious problem for cassava cultivation which is grown extensively in Kerala and Tamil Nadu. It is reported that cassava mosaic may reduce the tuber yield of cassava between 19.5—26.0 per cent (THANKAPPAN & CHACKO, 1976). Information on ecological aspects of *B. tabaci* under Kerala conditions is wanting and hence the present investigations.

MATERIALS AND METHODS

The study was undertaken in CTCRI, Trivandrum. Population of *B. tabaci* on three leaves per plant (each representing lower, middle and upper part of the plant) and on 50 plants was recorded from planting till harvest. The absolute maximum and minimum temperature, absolute percentage of relative humidity and total rainfall were also recorded and data were statistically analysed.

RESULTS AND DISCUSSION

The data (Fig. 1) revealed that the population of aleyrodids was found to be present throughout the year, peak infestation being in January, March and June. The correlation coefficient between weather factors and the population level of *B. tabaci* on cassava are presented in Table 1. The increase in whitefly population was positively and significantly correlated with the increase in maximum temperature during 1975—76 and 1977—78. This result agreed with earlier findings (MURUGESAN

TABLE 1. The results of correlation coefficient between weather factors and whitefly populati n.

	1975-76	1976-77	1977-78
Max. temperature	0.8401*	0.2635	0.7651*
Min. temperature	—	0.4576	0.1092
Humidity	−0.4700	−0.4804	−0.0815
Rainfall	−0.3900	−0.7080	−0.1444

* Significant at 5% level.

[1] Present address: Entomologist (Pulses), Project Directorate, I.A.R.I. Regional Station, Kalyanpur, Kanpur-208 024.

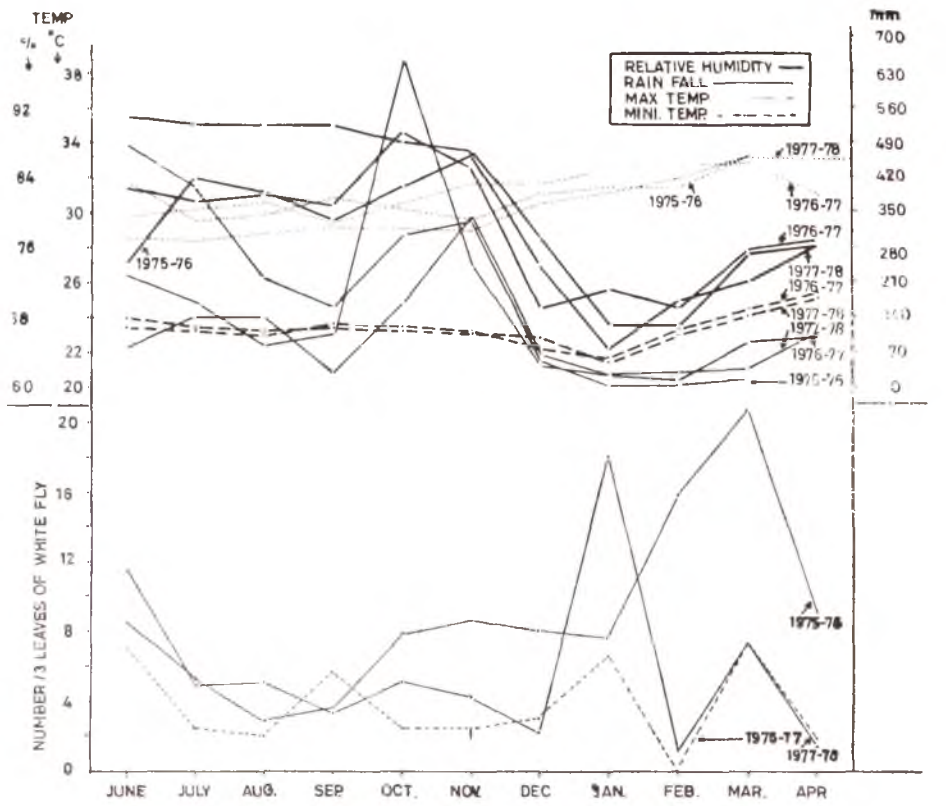

Fig. 1. Average no. of aleyrodid & meteorological data for 1975—76, 76—77 and 77—78 at Trivandrum (Kerala).

et al, 1977; DAVID *et al.*, 1973; BUTLER, 1938 a, b). Relative humidity, minimum temperature and rainfall had no significant correlation with the population of nymphs and adults.

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APHID-GALLS AND THEIR PARASITOIDS FROM KASHMIR, INDIA

R. C. BHAGAT[1]

Entomology Section, Sericulture Research Centre, P. B. No. 30, Mirgund, Kashmir (J & K), India 193 121

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Brief descriptions with illustrations of various aphid-galls collected from Kashmir, record of aphid species forming these galls and hymenopterous parasitoids attacking the gall-producing aphids are given.

(*Key words:* aphid galls, parasitoids, Kashmir)

The plant galls are formed by hypertrophy (overgrowth) and hyperplasia (excessive cell division), under the influence of aphids. MANI (1973), while describing the plant galls of India has given a preliminary account of a few aphid galls from Kashmir. Recently the investigation of aphids and their parasitoids of Kashmir in detail has been conducted by BHAGAT (1980, 1981). During the course of survey of aphid-fauna and their parasitoids in Kashmir, the present author encountered many aphid-galls on various plant species. The present communication gives brief descriptions of various aphid-galls collected with records of aphid species forming these galls together with their internal hymenopterous parasitoids, attacking these gall-making aphid species in Kashmir, the same are incorporated in Table 1.

It has also been observed that the hymenopterous parasitoids invade gall-making aphids through holes in different gall studied. In *Ulmus* spp. more than one aphid species participate in causing galls and showed high percentage of parasitization by an aphidiid parasitoid, *Areopraon lepelleyi* (WATERSTON). *Populus* gall aphids have been found to be attacked by an aphelinid parasitoid, *Protoaphelinus nickolskajae* (JASHNOSH), occurring in abundance during July to August in this region. *Aphelinus mali* HALDMAN, parasitoid of *Eriosoma lanigerum* (HAUSMANN) was observed to be almost checking the aphid population to great extent, thereby showing not common shoot axis galls on apple trees in Kashmir.

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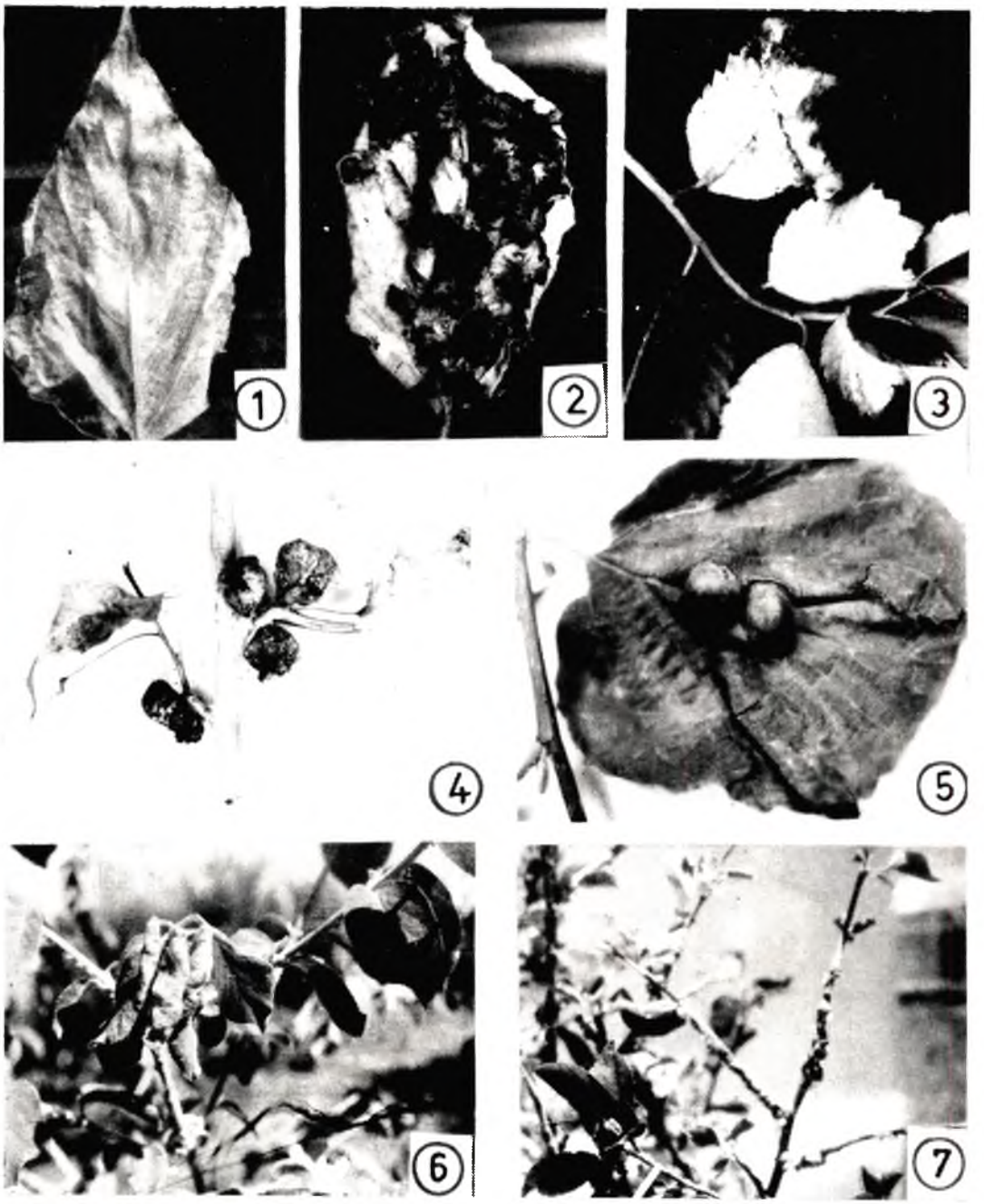
[1] Present address: P. G. Department of Zoology, Kashmir University, Srinagar, Kashmir-190 006, (J & K).

TABLE 1. Aphid galls and their parasitoids.

Type of aphid gall	Plant species	Aphid species	Primary parasitoid	Hyperparasitoid	Locality	Date
Simple Leaf Gall:						
a) Leaf fold gall (fig. 6)	*Lonicera quinquelocularis*	*Prociphilus* sp.	*Ephedrus plagiator (Nees)*	Unknown	Zabervan	30-5-1976
b) —do—	—do—	—do—	*Ephedrus srinagarensis* Stary' and Bhagat	*Coruna* sp.	Pari Mahal	25-5-1975
c) —do—	—do—	—do—	*Kashmiria aphidis* Stary' and Bhagat	—do—	—do—	25-5-1975
d) Simple leaf roll gall	*Ailantus altissma*	*Tetraneura* sp.	*Ephedrus plagiator (Nees)*	Unknown	Ducksum	17-8-1978
e) —do— (fig. 3)	*Ulmus laevigata*	*Erisoma* nr. *ulmi* Rilley	*Arepraon lepelleyi-* (Waterstone)	Unknown	Khilanmarg	14-5-1978
f) —do—	*Ulmus wallichiana*	*Indiochaitophorus furcetus* Verma	Unknown	—do—	Srinagar	15-6-1977
Leaf Pouch Gall:						
a) 2-4 galls on the surface of the leaf, epiphyllous cylindrical-compressed and deeply furrowed (fig. 1)	*Populus ciliata*	*Pemphigus immunis* Buckton	*Protoaphelinus nickolskajae* (Jashnosh)	*Aphidencyrtus aphidivorus* (Mayr.)	Dachigam	12-5-1976
b) Epiphyllous, clavate and lop-sided (fig. 2)	*Ulmus wallichaina*	*Schizoneurella indica* Hille Ris Lambers	*Areopraon lepelleyi* (Waterstone)	*Prionomitus* sp.	Hazratbal, Srinagar	12-5-1976
c) Botton shaped pouch gall on the leaf surface (fig. 5)	*Parattiopsis jacquemontiana*	*Neothoracaphis* sp.	Unknown	Unknown	Gulmarg	21-7-1979
Shoot Axis Gall:						
a) Bulging of cortex (fig. 7)	*Pyrus malus*	*Eriosoma lanigerum* (Hausamnn)	*Aphelinus mali* Haldman	Unknown	Srinagar	April to December, 1976
Stem Gall:						
a) Globose, sessile and thick walled, solitary or 1—2 grouped together (fig. 4)	*Populus alba*	*Pemphigus napeus* Buckton	*Protoaphelinus nickolskajae* (Jashnosh)	*Aphidencyrtus aphidivorus* (Mayr.)	Srinagar	13-8-1978
b) —do	*Populus caspica*	*Pemphigus mordvilkoi* Cholodkovsky	—do—	Unknown	Srinagar	12-8-1977



1. Leaf pouch gall of *Populus ciliata*; 2. Leaf pouch gall of *Ulmus wallichiana*; 3. Simple leaf roll gall of *Ulmus laevigata*; 4. Stem gall of *Populus alba*; 5. Leaf pouch gall of *Parattiopsis jacuemontiana*; 6. Simple leaf fold gall of *Lonicera quinquelocularis*; 7. Shoot axis gall of *Pyrus malus*.

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SILK PERCENTAGE AND EFFECTIVE RATE OF REARING OF ERISILKMOTH, *PHILOSAMIA RICINI* HUTT. (LEP : SATURNIIDAE) REARED ON TWO HOST PLANTS AND THEIR COMBINATIONS

K. L. JOSHI & S. D. MISRA

Department of Zoology, University of Jodhpur, Jodhpur (Rajasthan), India 342 001

(Received 13 December 1980)

The silk percentage (SR) and effective rate of rearing (ERR) of erisilkmoth, *Philosamia ricini* Hutt. were studied by rearing the worms on four combinations of two host plants (castor, *Ricinus communis* and tapioca, *Manihot utilisima)* viz. TT (I—V instar larvae reared on the leaves of tapioca), TC (I—III instar larvae reared on the leaves of tapioca while IV—V on castor), CT (I—III instar larvae reared on castor leaves while IV—V on tapioca leaves) and CC (I—V instar larvae reared on castor leaves alone), at 26±2 C temp and R.H. 90±5% (upto IV instar) and 60±5% to the rest of the stages. The silk ratio is maximum in dietary regimen CC and minimum in dietary regimen TT whlie in TC it is higher than dietary regimen CT. The effective rate of rearing (ERR) is almost similar in dietary regimen TT and CT while it is slightly lower in dietary regimen CC than in TC.

(Key words: silk percentage, effective rate of rearing, erisilkmoth, *Philosamia ricini* host plants, combinations)

INTRODUCTION

KUSHWAHA & VERMA (1978) have reared the erisilkworm, *Philosamia ricini* HUTT. on castor *(Ricinus communis)*, variety J_1, similarly POONIA (1976) on local castor cultivar, CHOWDHARY (1974) on different stages of castor leaves and tapioca, SACHAN & BAJPAI (1972) on four castor varieties, KAPIL (1967) on two castor cultivars and tapioca, but no work has been done on the interchange of food plant during larval stages of the erisilkmoth, *P. ricini* to obtain the silk ratio and effective rate of rearing.

The present effort was, therefore, undertaken to find out the effect of different combinations of food on the weight of sex specific green cocoon, cocoon shell (cut cocoon), silk ratio and effective rate of rearing.

MATERIAL AND METHODS

After microscopic examination of ten female moths, their eggs were used for four experiments (Table 1), each experiment started with 400 worms, as follows:

Tender leaves of castor (*R. communis*) variety *GCH-3*, or tapioca (*Manihot utilisima*) were fed to I and II instar larvae, more mature leaves to III instar while most mature leaves were fed to IV and V instar larvae.

At the time of spinning, the sexes were separated and cocoons were made in *Chandraki*. After 3 days of spinning the green cocoons were weighed, having ten replicates, each replicate consist of ten cocoons*. Similarly cocoon shells were weighed after removal of pupae from the green cocoons. The silk ratio was calculated by the following formula:

$$\text{Silk Ratio} = \frac{\text{Weight of cocoon shell}}{\text{Weight of green cocoon}} \times 100$$

* In Table, the values are given as mean of hundred.

TABLE 1. Laboratory rearing experiments on erisilkworm, *Philosamia ricini* HUTT. with fixed abiotic conditions and varying host plants.

	Dietary regimen	Instar I	Instar II	Instar III	Instar IV	Instar V	Rest of the stages
Biotic conditions	TT	Tapioca	Tapioca	Tapioca	Tapioca	Tapioca	—
	TC	Tapioca	Tapioca	Tapioca	Castor	Castor	—
	CT	Castor	Castor	Castor	Tapioca	Tapioca	—
	CC	Castor	Castor	Castor	Castor	Castor	—
Abiotic conditions	Temp.	26±2°C	26±2°C	26±2°C	26±2°C	26±2°C	26±2°C
	R.H.	90±5%	90±5%	90±5%	90±5%	60±5%	60±5%

TABLE 2. Weight (in gms) of sex specific green cocoon and cocoon shell of erisilkmoth, *Philosamia ricini* HUTT. reared at four dietary regimen.

Dietary regimen	Male green cocoon (A)	Female green cocoon (B)	Male cocoon shell (C)	Female cocoon shell (D)	Level of significance, P Between A & B	Between C & D
TT	0.941±0.080	1.335±0.098	0.122±0.010	0.120±0.011	0.001	NS
TC	2.671±0.131	3.060±0.075	0.432±0.013	0.445±0.019	0.001	NS
CT	1.885±0.150	2.139±0.137	0.241±0.015	0.248±0.016	0.01	NS
CC	2.650±0.130	3.106±0.095	0.447±0.021	0.456±0.021	0.001	NS
S.Em±	0.08	0.04	0.012	0.012	—	—
C.D. at 5%	0.28	0.11	0.034	0.033	—	—

The effective rate of rearing (ERR) was calculated as number of green cocoons produced out of 400 worms for each of the dietary regimen.

RESULTS AND DISCUSSION

It appears from Table 2, that the weight of male green cocoon and male cocoon shell are significantly different from each other, in all the four dietary regimen but the difference between dietary regimen TC and CC is non-significant. Similar results were obtained for female green cocoon and cocoon shell.

The difference between the weights of male and female green cocoons for all the dietary regimen, is significant at 0.1% level of significance, except when the worms were allowed to feed on dietary regimen CT, where the values differ at 1% level of significance. Surprisingly, the difference between the weight of male and female cocoon shell in all the four dietary regimen is non-significant.

It is also apparent from Figures 1 & 2 that the values of regression equation for male ($Y = -0.0660 + 0.1851\ x$, $r = 0.9732$)

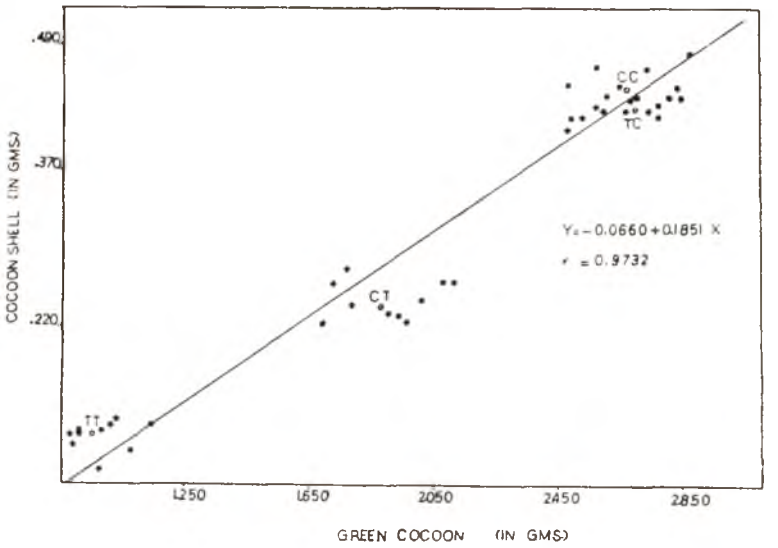

Figure 1. Relationship between male green cocoon and male cocoon shell of erisilkmoth, *Philosamia ricini* HUTT. reared at four dietary regimen. Mean values for each diet are circled.

and female (Y = —0.1405+0.1901 x, r = 0.9890) are almost same showing that male green cocoon shows the same relationship with cocoon shell as female green cocoon, although the male green cocoon is significantly lighter in weight.

Interestingly, male being significantly lighter in weight gives more of it's body weight to silk production but in contrast, less proportion of female body weight is associated with silk production, because retained energy will be utilized for egg production and their laying.

In the dietary regimen CC, the mean silk ratio (Table 3) is highest (15.79%) indicates that castor being a principal food plant (GHOSH, 1949) gives maximum production of the body weight of erisilkmoth, *P. ricini*, to silk formation. In dietary regimen TT this proportion is minimum (11.21%) because tapioca being an alternative host plant (GHOSH, 1949; KAPIL, 1967), the worms may result in partial starvation, as has been observed (MISRA & JOSHI, 1979, unpublished data) by us that erisilkworms ingested significantly minimum amount of food (in dry weights) than remaining other three dietary regimen. Similarly, when the castor was allowed to be fed to IV and V instar larvae (dietary regimen TC) the mean silk ratio (15.36%) was of category II, while in dietary regimen CT the mean silk ratio (12.24%) of category III. These results indicate that, when tapioca was fed to IV and V instar particularly, the silk synthesis ceased. LEGAY (1958) has also reported that, in all the stages of larval life the V instar is more essential for any change, either qualitative or quantitative, in food, is reflected consistently through large variation in the development of silk gland and secretory intensity of silk.

In the dietary regimen TT and CT, the value of effective rate of rearing, is

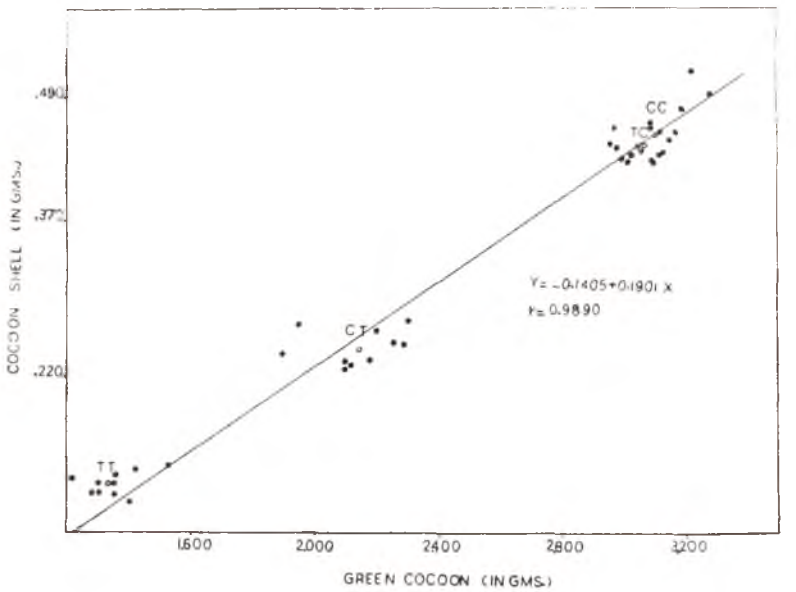

Figure 2. Relationship between female green cocoon and female cocoon shell of erisilkmoth, *Philosamia ricini* HUTT. reared at four dietary regimen. Mean values for each diet are circled.

similar but however, in the dietary regimen CC, the value of effective rate of rearing is less than dietary regimen TC.

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A NEW SPECIES OF *MACRONEMURUS* COSTA (MYRMELEONIDAE: PLANIPENNIA, NEUROPTERA) FROM INDIA

S. K. GHOSH

Zoological Survey of India, Calcutta—12, India

(Received 4 October 1980)

Macronemurus punjabensis, sp. nov., is described along with a key to other two Indian species.

(*Key words:* new species of *Macronemurus* Costa, a key to the species from India)

A new species of the genus *Macronemurus* Costa from India, whence two other species, viz., *M. trivittatus* Banks (1911) and *M. nefandus* (Walker) (1853), are already known, is being described here for the sake of ready reference, a key to all the three Indian species have been incorporated in this work. The study has been based on the old material lying in the National Zoological Collections of Zoological Survey of India.

Macronemurus punjabensis, sp. nov. (Figs. 1—4)

Mandibles, maxillae, labium, labrum, clypeus and frons brown, tip of the first being prominently dark. Antennae brown, but the margins of pedicels ringed dark-brown; a triangular dark-brown patch between the antennal bases. Vertex concolorous with antenna and with indistinct brownish spots. Eyes black. Pronotum yellow, longer than broad, with short and long white hairs, posterior corner with a black spot on either side. Meso— and metanota concolorous with pronotum but blackish in the principal convex areas. Legs: femora and tibiae of fore— and hind pair brown with moderately long black bristles and also with short and long white hairs; hind femur brown at base but black for the 3/4 of its distal length, with black and white long bristles and also with a group of fine short, black and white hairs on the inner side near base; hind tibia yellowish throughout except the blackish tip, with sparse vestiture of black and white bristles and spurs equal to two basal tarsal segments taken together; tarsi brown with short black hairs, 5th tarsal segment as long as three basal tarsal segments taken together; claws red. Wings (Fig. 1) hyaline; acute at tip; Sc and R_1 yellow with brown bands; other veins whitish except a few of the crossveins in the radial field, several on the disc and all in the maculated and costal areas either wholly or partially brown; forewing: dark brown; with rounded or irregular small brown spots at base, on the disc and along the hind margin; costal veinlets simple; pterostigma yellow; Rs arising beyond the cubital fork; 5 cross veins before Rs; a row of gradate veinlets in the apical field; all the veins beyond pterostigma and along hind margin forked; hindwing: smaller and narrower; with spots smoky brown, irregular and restricted below apex, otherwise similar to forewing. Abdomen: shorter than wings; black throughout except the brown 2nd and 3rd segments; segmental ciliations black and white; ectoproct and genitalia in male, as in Fgs. 2 & 3; tip of abdomen in female, as in Fig. 4.

Macronemurus punjabensis, sp. nov. ♂: Fig. 1. fore- and hindwings.

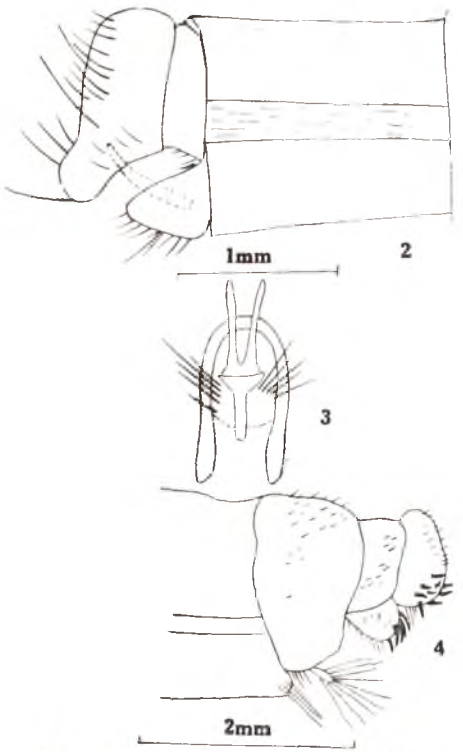

Fig. 2. tip of abdomen showing ectoproct (lateral view); 3. gonarcus and paramere (ventral view); ♀: 4. tip of abdomen (lateral view).

Measurements: ♂ (Holotype): length of forewing, 27 mm; of hindwing, 26 mm. ♀ (Allotype): length of forewing, 30 mm, of hindwing, 28 mm. 1 ♀ (Paratype): length of forewing, 28 mm, of hindwing, 27 mm.

Material examined: **Holotype**, Regd. no. 921/H_{12}, Khewra, Saltrange, INDIA: PUNJAB Sta-6, 24. ix—x. 1930, Coll. S. L Hora & H. S. Pruthi; **allotype** and **paratype**, Regd. nos. 922/H_{12} and 923/H_{12} respectively, collection data same as for the holotype; repository of types: Zoological Survey of India, Calcutta.

Remarks: It is very closely allied to *M. nefandus* (Walker) (Walker 1853) by the colouration of the vertex and leg and also in having unforked costal veinlets from the base of the wings to the pterostigma, but it can be readily distinguished from it by the yellow pterostigma and forewing being maculated brown almost throughout.

KEY TO THE INDIAN SPECIES OF MACRONEMURUS

1. Head black; pronotum with three black stripes, but without any spot ..... *trivittatus* Banks

— Head coloured other than black; pronotum with stripes less than three in number, when present, or totally absent, but with spots 2

2. Head testaceous; pronotum with a ferrugineous stripe and paired spots on either side; forewing immaculate; both wings with whitish pterostigma ..... *nefandus* (Walker)

— Head brown; pronotum without stripe, but with a black spot on either side; forewing maculated brown almost throughout; both wings with yellow pterostigma ..... *punjabensis* sp. nov.

Acknowledgements: The author is indebted to the Director, Zoological Survey of India, Calcutta for the necessary facilities provided during the work and thanks are also due to Sri. D. K. MANDAL, Asst. Zoologist for material help.

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Entomon, 1982, *Vol.* 7, *No.* 1, *pp.* 115 *to* 118

A NEW GENUS AND SPECIES OF ANOMALONINAE (HYMENOPTERA, ICHNEUMONIDAE) FROM INDIA

P. K. NIKAM

Department of Zoology, Marathwada University, Aurangabad, India 431 004

(Received 10 May 1981)

A new genus and species of Anomaloninae (Ichneumonidae) *Indagrypon raoi*, collected from Maharashtra, India is described. The relationships of the genus are discussed.

(Key words: Indagrypon raoi gen. nov., sp. nov. from India)

The Anomaloninae is a moderately large sub-family of Ichneumonidae found in most regions of the world. Most species are endophagous parasites of lepidopterous larvae. The genera of Anomaloninae have been studied and redefined recently (Townes, 1961, 1971; Gauld, 1976). Amongst material collected from Maharashtra, India, is an undescribed species which could not be placed to genus using either of the above works. Subsequent studies of this species and other Anomaloninae at the British Museum (Natural History), London have shown that it belongs to a new genus. This genus is described below and compared with related genera. The terminology and indices used follow Gauld (1976). The drawings were made using squared eyepiece.

Indagrypon, gen. nov.

Type-species *Indagrypon raoi*, sp. nov.

The name is derived from the country's name, India, and the known genus *Agrypon*.

Occipital carina posterior to ocelli interrupted. Frons below ocelli with a median vertical carina and a pair of curved carinae lateral to antennal sockets. Clypeus (Fig. 2) with a median tooth and a pair of weeker teeth laterally. Scape truncate, 2 × the length of pedicel. Mesoscutum with a strong, nearly complete transverse suture in front of scuto-scutellar groove, notauli week. Epicnemial carina (Fig. 1) at the front edge of mesopleurum, reaching up to lower quarter of pronotum. Propodeum not globose, basally reticulate, apically transversely striate, its apex reaching beyond apex of hind coxa (Fig. 1). Fore coxa with a strong carina on anterior side mid and hind tibiae with two spurs. Fore wing (Fig. 1) with 2 + 3*rm* proximal to 2*m*—*cu*; 1*m*—*cu* and Cu_{1a} basally separated from each other; CI small. Hind wing (Fig. 1) with Cu_1 + *cua* straight; distal abscissa of Cu_1 present. Basal segments of gaster (Fig. 1) elongate; ovipositor straight, long; valvula 2 (Fig. 7) apically rounded, without a distinct subapical notch; valvula 3 long; ninth sternite (Fig. 5) 0.80 as long as broad; gonolaciniae (Fig. 4) distally abruptly angled about 70°, apodeme short; aedeagus (Fig. 6) with teeth on apex and median third; gonosquamae (Fig. 3) extended posteriorly volsella (Fig. 4) elongately oval.

Indagrypon Raoi, sp. nov.

The name *raoi*, is in honour of Prof. S. N. RAO, Department of Zoology,

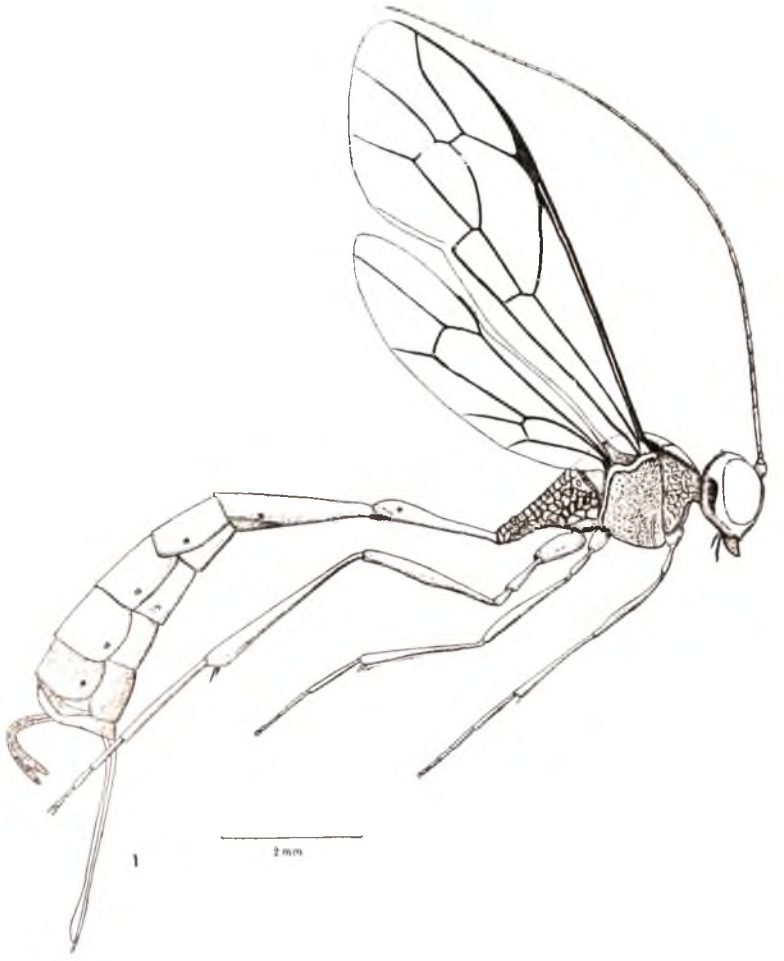
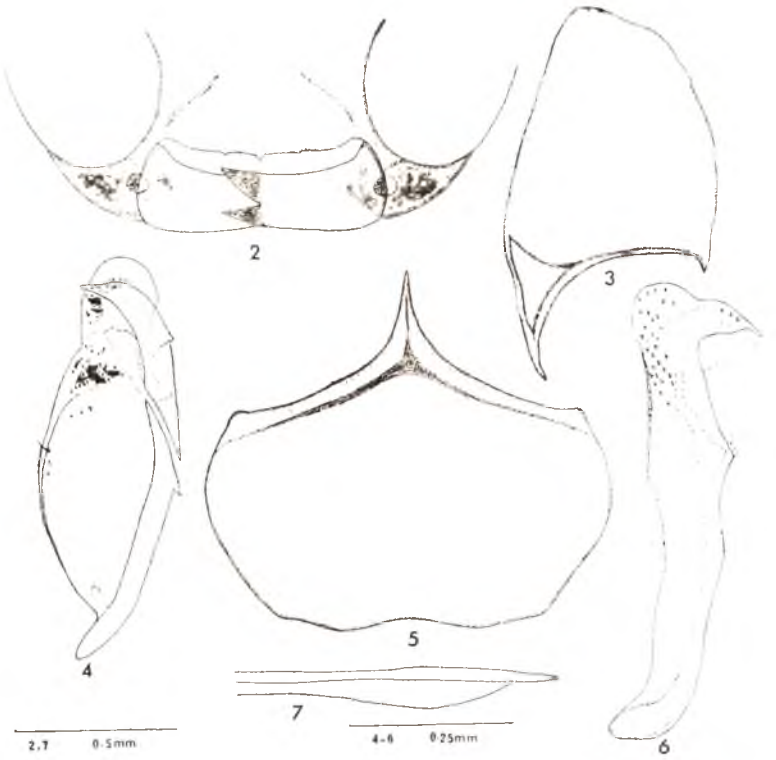


Fig. 1. *Indagrypon raoi*, gen. nov., sp. nov. ♀.

Marathwada University, Aurangabad, India.

Face slightly convex, medially longitudinally sulcate, pubescent, closely punctate, apically 0.65—0.80 as broad as at base; lower face centrally flat, 0.65—0.70 as broad as the distance from medioclypeal apex to antennal base. Clypeus pubescent, basal two-thirds convex, finely, sparsely punctate, apical third concave, smooth, extreme apex emarginate. Mandible basally simple, apically not twisted, lower tooth 0.80 as long as upper tooth. Interocellar distance less than orbital-ocellar distance. Antenna shorter than body; fourth flagellar segment 3 × as long as broad; white band on antenna absent in male and female. Eyes glabrous, emarginate. Head behind eyes buccate; accessory carina on occiput absent.

Pronotum with distinct longitudinal striations, irregular furrows, lower corner truncate and transverse dorsal pronotal crease, without pronotal tooth. Mesopleurum pubescent, strongly punctate, sternaulus absent. Posterior transverse carina on mesosternum complete; postpectal carina complete. Scutellum weakly concave, with carina at base. Metapleurum



Figs. 2—7. *Indagrypon raoi*, gen. nov., sp. nov. 2. Lower face, anterior view; 3. Gonosquama; 4. Volsella; 5. Ninth abdominal sternite; 6. Aedeagus; 7. Valvula 2, apex, lateral view.

pubescent, longitudinally, strongly striate. Legs of male stouter than female; trochanteral index 1.25—1.60; second tarsal segment of male not explanate and without sensory hair; first hind tarsal segment of male 2.40—2.50 × the second and 5.20—5.50 × the fifth segment; claws curved. Fore wing with *Rs* almost straight: distal anterior angle of subdiscoidal cell obtuse; hind wing with 7—9 hamuli on R_1; indices: BAI = 1.00; BI=1.12—1.71; CI = 0.14—0.33; LCI=0.10—0.16; DBI = 0.45—0.55; MI = 1.57—2.14; NI = 0.25—0.62; RI= 0.90—1.50.

Tergite 1 of gaster as long as tergite 2; tergite 2, 1.80—1.90 × as long as tergite 3 and 6.00—7.00 × its apical depth; tergite 3, 1.70—2.00 × as long as deep; indices : DAI = 1.75—2.00; LAI=6.00—9.00; PI= 4.00—5.50; ovipositor 2.30—2.50 × the apical depth of gaster and 1.40—1.65 × as long as tergite 1; valvula 3 as long as tergite 2, 1.80—1.90 × the length of tergite 3 and 1.40—1.70 × as long as apical depth of gaster; ninth abdominal sternite transverse, posteriorly truncate, anteriorly medially depressed; distivolsella slender, 0.50 as long as broad; teeth numerous on distivolsella and basivolsella; paramere proximally blunt; aedeagus not expanded apically, without protuberance, dorsally convex, strongly sclerotized, ventrally concave.

Reddish-brown. Face, clypeus light brown/brown/reddish; eyes, vertex, interocellar space, mandibular teeth, mesoscutum/complete thorax, apex of gaster, claws and

male genitalia except aedeagus black; valvula 3 blackish; legs brown/blackish-brown; flagellum blackish-brown.

Holotype: ♀, INDIA: MAHARASHTRA, Aurangabad, Himayatbagh. 29.ix.1975, Coll. K.S. Heble. **Paratypes** 2 ♀♀, 6 ♂♂, 29.ix.1975, 4 ♂♂, 24.ix.1976, other data as holotype. (Depository: Holotype—Zoological Survey of India, Calcutta, India; paratypes—1 ♀ 1 ♂—British Museum (Natural History), London; rest of the material with author.)

Distributin: India.

Remarks: *Indagrypon* resembles *Agrypon* Foerster in having carinae on anterior edge of fore coxae, elongate basal segments of gaster, 2 purs on mid tibia, small cubital index (CI) and 2 + 3*rm* proximal to 2*m*—*cu*. It runs to this genus in the key given by Gauld (1976). However, the new genus differs from *Agrypon* in the following characters: epicnemial carina reaching up to lower quarter of pronotum, propodeal apex reaching beyond apex of hind coxa, valvula 3 long and valvula 2 apically rounded, without a distinct subapical notch. A single undescribed North American species of *Agrypon* has an elongate ovipositor but this species has a distinct subapical notch. In addition, *Indagrypon* has also curved carinae lateral to antennal sockets, different male genital complex and occipital carina interrupted. It also has a transverse suture before the scuto-scutellar groove. A single Palaearctic species doubtfully referable to *Agrypon*, *A. arquatum* (Grav.) also has a suture in this position. This species however lacks the distal abscissa of Cu_1 in the hind wing. In the generic key of Townes (1971) *Indagrypon* would run to the tribe Podogastrini. It differs from all other Podogastrini in having a carina on fore coxa and a distal abscissa of Cu_1 in the hind wing and the clypeus with lateral teeth. *Perisphincter* Townes has a clypeus similar to that of *Indagrypon* but species of *Perisphincter* differ in having the ovipositor shorter and strongly decurved, not having the fore coxal carina completely encircling the coxa. In view of these differences this species could not satisfactorily be assigned to any described taxon but clearly represents a new genus. *Indagrypon*, gen. nov. may be included in the key to the genera given by Gauld (1976) as follows:

13. Fore coxae, when viewed ventrally, with a carina discernible along their anterior edge. Fore wing with cubital index less than 0.60 ..... 13a

— Fore coxae, when viewed ventrally, smooth, without a trace of a carina along anterior edge 14

13a. Clypeus with a single median tooth; mesoscutum without a suture before scuto-scutellar groove; apex of ovipositor with distinct subapical notch ..... *Agrypon* Foerster

— Clypeus with a median and a pair of lateral teeth; mesoscutum with suture before scuto—scutellar groove; apex of ovipositor without a subapical notch ..... *Indagrypon*, gen. nov.

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REPORTS AND NEW RECORDS

EUCHRYSOPS CNEJUS FAB. (LYCAENIDAE : LEPIDOPTERA), A NEW PEST OF *CITRUS MEDICA* LINN VAR. *ACIDA* HOOK (KAGZI NIMBU)

TARLOK SINGH

Zoology Department, Panjabi University, Patiala, India 147 002

(Received 14 March 1981)

The larvae of *Euchrysops cnejus* Fab., a butterfly, has been found for the first time attacking emerged and the tender leaves of *Citrus medica* Linn. var. *acida* Hook (Kagzi Nimbu), and thus causing a damage of serious nature.

(Key words: Euchrysops cnejus, Lycaenidae, Lepidoptera, citrus pest)

One hundred and twenty insects and mites attack citrus plants in India (PRUTHI & MANI, 1945) causing about 30% loss to fruits, but no record of *Euchrysops cnejus*, attacking *Citrus medica* LINN. var. *acida* Hook (*Kagzi nimbu*) is available.

The larvae of *E. cnejus*, a butterfly having metalic blue spots on the hind wings, belonging to Fam. Lycaenidae (Lepidoptera) was observed attacking the leaves of the above mentioned citrus plant at the Campus of Panjabi University, Patiala, for the first time. The species had also been seen breeding abundantly on the leaves of *Clerodendrum inerme* (LINN.) (a hedge plant) grown in and around Campus.

The adults copulated in the morning hours and the female laid eggs singly on both sides of the newly formed tender leaves in the month of October. The eggs were white, round, sculptured and

Fig. 1 Showing larva eating up the leaf.

Fig. 2. Showing top leaves of the branch devoured by the larvae.

appeared like a volvox colony under microscope. The larva hatched after two days, was of pale greenish colour but attained green colour at maturity. Newly emerged larva started nibbling the leaf and continued till the leaf was devoured (Fig. 1), when it migrated to another leaf if the larval development was not completed. The pupation occurred after about 16 days and the adults emerged within 4—5 days. In case of heavy deposition of eggs on leaves of a branch, the emerging larvae eat up all the leaves leaving nude branches Fig. 2. As it is evident from the figures, the insect is capable of causing a serious damage which needs attention.

The identification of the pest was got confirmed from Zoology Department, Punjab University, Chandigarh.

REFERENCE

PRUTHI, H. S. & M. S. MANI (1945) Our knowledge of the insect and mite pests of citrus in India, and their control. *Scient. Monogr. imp. Counc. agric. Res.* India, 16—43.

OCCURRENCE OF *FUSARIUM EQUISETI* (CORDA) SACC. AS A FUNGAL PARASITE OF BRINJAL MEALY BUG *COCCIDOHYSTRIX INSOLITA* (GREEN)

P. V. GOPINATHAN, N. NASEEMA BEEVI & M. R. G. K. NAIR

Division of Entomology, College of Agriculture, Vellayani, Trivandrum 695 522

(Received 16 January 1981)

Fusarium equiseti, a fungal pothogen, is recorded as parasite of the brinjal mealy bug, for the first time.

(Key words: Fusarium equiseti, fungal parasite, brinjal mealy bug, *Coccidohystrix insolita)*

The brinjal mealy bug *Coccidohystrix insolita* (Green) (Psuedococcidae: Homoptera) was observed severely infected by *Fusarium equiseti* in the Agricultural College Farm, Vellayani, Kerala, during August—September 1979 at 27°C and relative humidity of 93%. About 30% of the population of the mealy bugs was found infected and mummified by the pathogen. In the dead mealy bugs the posterior part of the body was raised and stiff and in due course the body became completely stiff and the fungal mycelia emerged out from the integument.

The pathogen was isolated in pure culture on Czapek's medium from the dead insects and was identified at the Commonwealth Mycological Institute, U. K. Pathogenicity tests were conducted by spraying a spore suspension prepared from a 5 day old culture of the fungus on mealy bugs infesting the plant. There was hundred per cent mortality among the spraved mealy bugs in nine days after spraying. In the initial stage of infection the disease was slow to develop and the mealy bug showed sluggishness, loss of sensitivity and stoppage of feeding. Mycelial growth appeared after 48 hours of inoculation followed by dark greyish spots on head, abdomen and hind legs. The ovisacs also became dark grey due to sporulation of the fungus.

This is the first time *F. equiseti* is observed as a parasite of the brinjal mealy bug. Earlier it has been recorded infecting pupae and adults of *Melanogromyza hibisci* Spencer (SRIDHAR & KRISHNIAH, 1975) and *Nephotettix virescens* Stal. (DEVANESAN *et al.* 1979).

The authors are grateful to Dr. Anthony Johnston, Director, Commonwealth Mycological Institute, Kew, Surrey, England for identifying the fungus.

REFERENCES

DEVANESAN, S., ABRAHAM JACOB, SUMA KURUVILLA & SUSAMMA MATHAI (1979) Infection of *Nephotettix virescens* (Stal.) (Cicadellidae:

Hemiptera) by *Fusarium equiseti* (Corda) Sacc. *Entomon*, **4** (3), 304—305.

SRIDHAR, T. S. & KRISHNIAH (1975) *Fusarium equiseti* (Corda) Sacc. a fungus infecting the okra petiole maggot, *Melanogromyza hibisci* Spencer. *Curr. Sci.*, **44**, 447.

RECORD OF A NEW HOST PLANT OF *CERCOTHRIPS TIBIALIS* (BAGNALL)

S. C. DHIMAN & VINAY KUMAR

Dept. of Zoology, M. S. College, Saharanpur, India

(Received 11 April, 1981)

Cercothrips tibialis is here reported from a new host plant, *Ficus glomerata*.

(Key words: Cercothips tibialis, new host plant, *ficus glomerata)*

ANANTHAKRISHNAN & SEN (1980) reported *Careya arborea*, a wild shrub as host plant of *Cercothrips tibialis*. During the survey of District Saharanpur, another new host plant, i.e., *Ficus glomerata* Roxb. (Moraceae) has been found infested by this thrip. On this plant occurrence of this thrip has been studied throughout the year and it has been observed that it is only found on the ventral surface of the leaf. It inhabits the circular depressed area of *Paurosylla depressa* Crawf. (Homoptera-Psyllidae) gall. Occurrence of the thrip always on the ventral side of this gall, provide good shelter and honey dew secreted by aforesaid psyllid. The eggs, larvae, prepupae, pupa first and pupa second stages along with adults were observed throughout the year. Eggs were found laid with all the other life cycle stages on the ventral aspect of gall in the depressed area.

Abundance of these thrips is found especially in the months of March to October. Leaf fall of *Ficus glomerata* takes place in November and new foliage appears in December. Accordingly it infests the new foliage which also got the infection of *Paurosylla depressa* simultaneously. Breeding occurs throughout the year and no migration of this takes place from this plant to other host plant.

Acknowledgement: We are extremely thankful to Dr. T. N. ANANTHAKRISHNAN for identification of the thrips.

REFERENCE

ANANTHAKRISHNAN, T. N. & S. SEN (1980) *Taxonomy of Indian Thysanoptera*. Zoological Survey of India, Calcutta. pp. 152.

RECORD OF A NEW TINGID ON SUGARCANE

S. EASWARAMOORTHY, G. SANTHALAKSHMI & H. DAVID

Division of Entomology, Sugarcane Breeding Institute, Coimbatore-641 007

(Received 14 March 1981)

A tingid bug, *Abdastartus atrus*, is newly recorded to feed on the leaves of sugarcane crop.

(Key words: tingid bug, *Abdastartus atrus*, sugar cane crop *)*

During a field visit to Deccan Sugars and Abkari Company Ltd., Pugalur, Tamil Nadu, a new tingid insect was found to feed on the leaves of five to seven months old sugarcane crop (varieties *Co 62175* and *CoC 671*). This has been identified as *Abdastartus atrus* (Motsch). The nymphs were red in colour with densely reticulate body and wings. The adults were ash coloured and measured 2.5 to 3.5 mm long. Both nymphs and adults sucked the sap from leaves, mainly from ventral surface and caused characteristic yellow spots. As many as 2 to 12 nymphs and

1 to 5 adults were observed per leaf. The insects collected and caged on healthy plants of sugarcane in pots, caused the yellow spots. Box (1953) reported only *Abdastartus sacchari* Drake (confused with *A. tyrianus* Dist.) from Java, Sumatra and Formosa. This is the first record of *A. atrus* on sugarcane.

Thanks are due to the Director, Sugarcane Breeding Institute, Coimbatore for encouragement and the Director, British Museum, London for identifying the specimen.

REFERENCE

Box, H. E. (1953) *List of Sugarcane Insects*. Commonw Inst. Ent., London, 101 pp.

ANNOUNCEMENTS

International Conference on Phylogeny, Classification, and Natural History of Hydradephaga (Coleoptera)

It is proposed to hold an International Conference on Classification, Phylogeny and Natural History of Hydradephaga (Coleoptera), in conjunction with the joint meetings of the Entomological Societies of America, Canada & Onario to be held in Toronto, Ontario, Canada, from November 28 to December 2, 1982. Further information may be had from the organizers of the conference: Dr. G. William Wolfe, Department of Entomology and Economic Zoology Rutgers, The State University of N. J., Cook College, P. O. Box 231, New Brunswick, N. J. 08903 USA, or Dr. Robert E. Roughley, Department of Entomology, The University of Alberta, Edmonton, Canada T6G 2E3.

INTERNATIONAL JOURNAL OF ENTOMOLOGY

The Department of Zoology, University of Calicut proposes to bring out the first issue of the half-yearly *International Journal of Entomology*, in July 1982. The journal considers for publication, original research papers and brief communications in the following fields of Entomology: Physiology, Biochemistry, Systematics, Morphology, Histochemistry, Ultrastructure, Behaviour, Applied Entomology, Cytology and Genetics. The members of the Editorial Board are: Dr. U. V. K. Mohamed (Chief Editor), Dr. U. C. Abdurahiman (Executive Editor) and Dr. T. C. Narendran (Associate Editor). The Editorial Advisory Committee consists of: Dr. S. M. Alam, Dr. Z. Boucek, Dr. L. I. Gilbert, Dr. K. J. Joseph, Dr. D. Livingstone, Dr. Y. Matsumoto, Dr. N. C. Pant, Dr. N. R. Prabhoo and Dr. J. T. Wiebes. Further details may be had from: The Executive Editor, International Journal of Entomology, Department of Zoology, University of Calicut, Calicut 673 635, Kerala, India.

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